EXHIBIT L

Exhibit A-30
Invalidity Claim Chart for U.S. Patent No. 7,924,802 vs. IEEE 802.11n Draft 2.0

IEEE 802.11n Draft 2.0 ("802.11n D2.0") was completed in February 2007 and published in March 2007. 802.11n D2.0 anticipates asserted claims 1–4, 6–10, 13, 14, 17, and 21–24 of U.S. Patent No. 7,924,802 ("the '802 Patent") under 35 U.S.C. § 102. 802.11n D2.0 also renders obvious asserted claims 1–4, 6–10, 13, 14, 17, and 21–24 of the '802 Patent under 35 U.S.C. § 103, alone based on the state of the art and/or in combination with one or more other references identified in Exs. A-1–A-31, Cover Pleading, and First Supplemental Ex. A-Obviousness Chart.[1]

To the extent Plaintiff alleges that 802.11n D2.0 does not disclose any particular limitation of the asserted claims in the '802 Patent, either expressly or inherently, it would have been obvious to a person of ordinary skill in the art as of the priority date of the '802 Patent to modify 802.11n D2.0 and/or to combine the teachings of 802.11n D2.0 with other prior art references, including but not limited to the present prior art references found in Exs. A-1–A-31, Cover Pleading, First Supplemental Ex. A-Obviousness Chart, and the relevant section of charts for other prior art for the '802 Patent in a manner that would render the asserted claims of these patents invalid as obvious.

With respect to the obviousness of the asserted claims of the '802 Patent under 35 U.S.C. § 103, one or more of the principles enumerated by the United States Supreme Court in *KSR v. Teleflex*, 550 U.S. 398 (2007) apply, including: (a) combining various claimed elements known in the prior art according to known methods to yield a predictable result; and/or (b) making a simple substitution of one or more known elements for another to obtain a predictable result; and/or (c) using a known technique to improve a similar device or method in the same way; and/or (d) applying a known technique to a known device or method ready for improvement to yield a predictable result; and/or (e) choosing from a finite number of identified, predictable solutions with a reasonable expectation of success or, in other words, the solution was one which was "obvious to try"; and/or (f) a known work in one field of endeavor prompting variations of it for use either in the same field or a different field based on given design incentives or other market forces in which the variations were predictable to one of ordinary skill in the art; and/or (g) a teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill in the art to modify the prior art reference or to combine the

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[1] Samsung is investigating this prior art and has not yet completed discovery from third parties, who may have relevant information concerning the prior art, and therefore, Samsung reserves the right to supplement this chart after additional discovery is received. To the extent that any of the prior art discloses the same or similar functionality or feature(s) of any of the accused products, Samsung reserves the right to argue that said feature or functionality does not practice any limitation of any of the asserted claims, and to argue, in the alternative, that if said feature or functionality is found to practice any limitation of any of the asserted claims in the '802 Patent, then the prior art reference teaches the limitation and that the claim is not patentable.

teachings of various prior art references to arrive at the claimed invention. It therefore would have been obvious to one of ordinary skill in the art to combine the disclosures of these references in accordance with the principles and rationales set forth above.

The citations to portions of any reference in this chart are exemplary only. For example, a citation that refers to or discusses a figure or figure item should be understood to also incorporate by reference that figure and any additional descriptions of that figure as if set forth fully therein. Samsung reserves the right to rely on the entirety of the references cited in this chart to show that the asserted claims of the ’802 Patent are invalid. Citations presented for one claim limitation are expressly incorporated by reference into all other limitations for that claim as well as all limitations of all claims on which that claim depends. Samsung also reserves the right to rely on additional citations or sources of evidence that also may be applicable, or that may become applicable in light of claim construction, changes in Plaintiff’s infringement contentions, and/or information obtained during discovery as the case progresses.

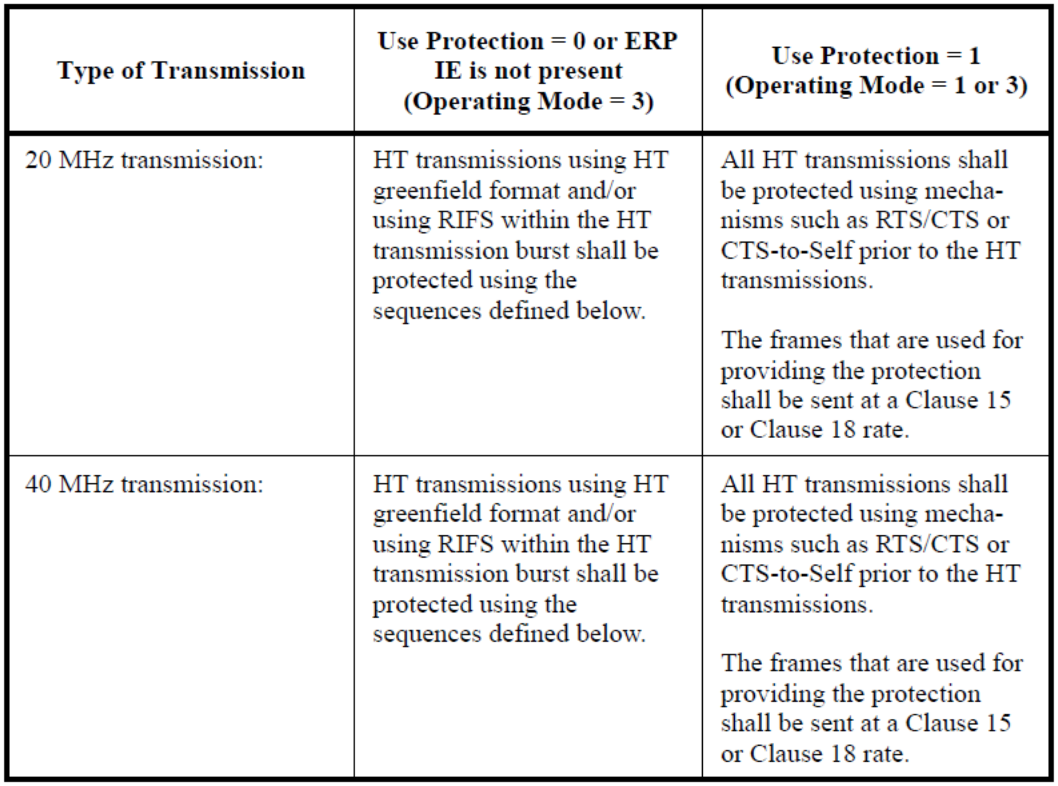
Claim 1 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
[1.1] A method of transmitting information in a wireless communication channel comprising:	To the extent the preamble is limiting, 802.11n D2.0 discloses “A method of transmitting information in a wireless communication channel comprising.” See, e.g.: **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17.

Claim 1 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format*: packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format*: packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format*: HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission (as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.

Claim 1 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
[1.2] transmitting first information across a first frequency range using a wireless transmitter, the first frequency range having a first center frequency, a first highest frequency, and a first lowest frequency; and	802.11n D2.0 discloses “transmitting first information across a first frequency range using a wireless transmitter, the first frequency range having a first center frequency, a first highest frequency, and a first lowest frequency.” See, e.g.: **high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19 **non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that

<table>
<tr><th>Claim 1 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>
is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

Table n49—Protection requirements for Operating Modes of 1 and 3



<table>
<tr><th>Type of Transmission</th><th>Use Protection = 0 or ERP IE is not present (Operating Mode = 3)</th><th>Use Protection = 1 (Operating Mode = 1 or 3)</th></tr>
<tr><td>20 MHz transmission:</td><td>HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.</td><td>All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions.
The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.</td></tr>
<tr><td>40 MHz transmission:</td><td>HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.</td><td>All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions.
The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.</td></tr>
</table>

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:

a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:

1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
</td></tr>
</table>

Claim 1 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20. NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames). b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

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<tr><th>Claim 1 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
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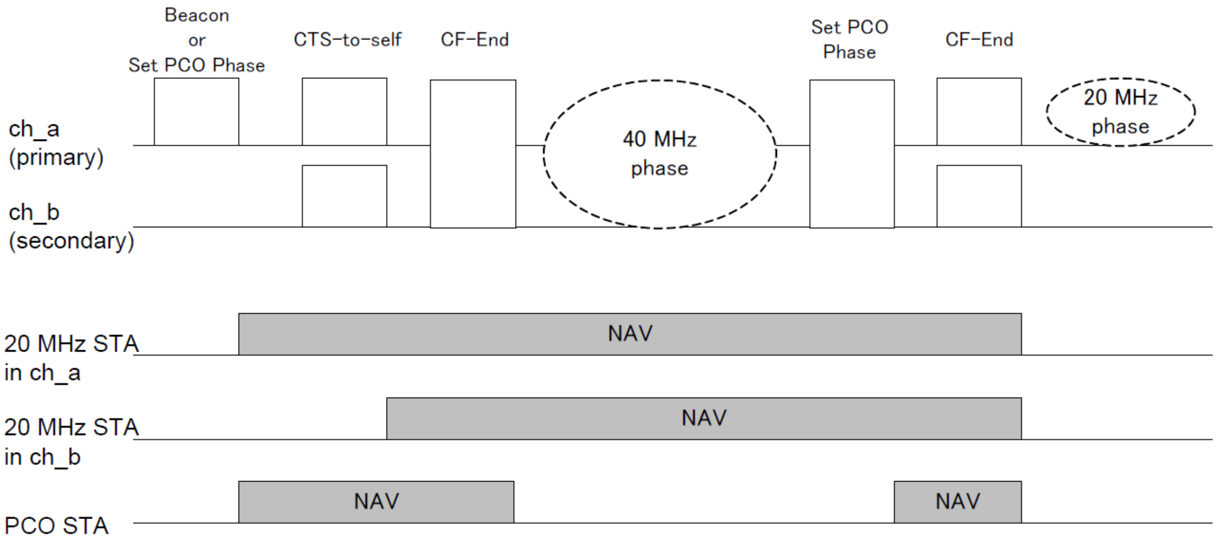

A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU.

During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel.

During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS.

A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS.

The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

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Claim 1 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 1 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

Claim 1 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

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	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

Claim 1 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t \right) \right\}$ (20-1) where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

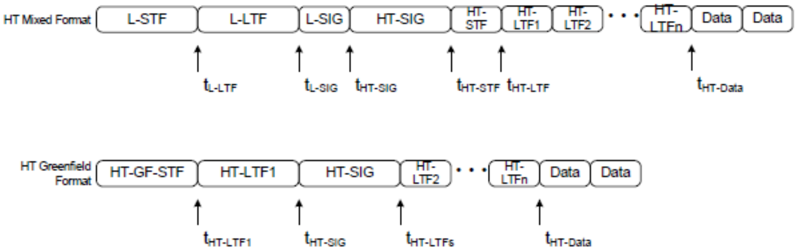


Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right)T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \quad (20\text{-}2)$$

where

$t_{L-LTF} = T_{L-STF}$

$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$

$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$

$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1}) \\ & + r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2)T_{HT-LTFs}) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \qquad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\text{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\text{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j 2\pi k \Delta_F t) \qquad (20\text{-}4)$$

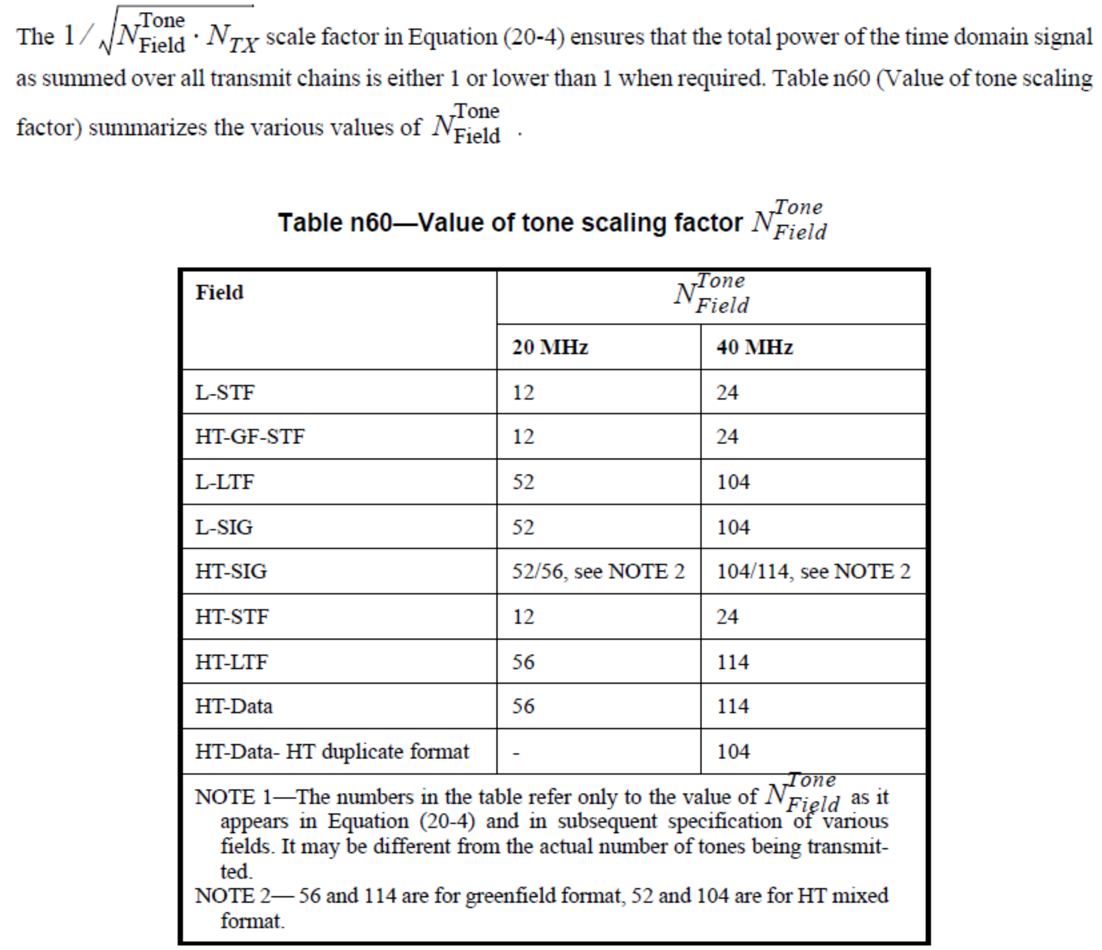
This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \qquad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \qquad (20\text{-}6)$$

Claim 1 of the ’802 Patent	Prior Art Reference – 802.11n D2.0



The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	40 MHz
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

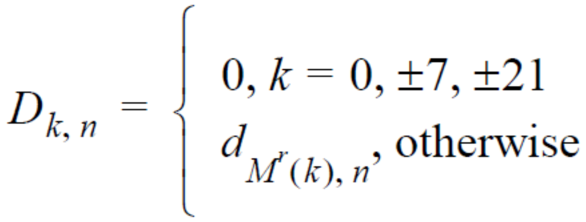
<table>
<tr><th>Claim 1 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

See, e.g., 802.11n D2.0 § 20.3.8

20.3.9.4.3 The HT SIGNAL field

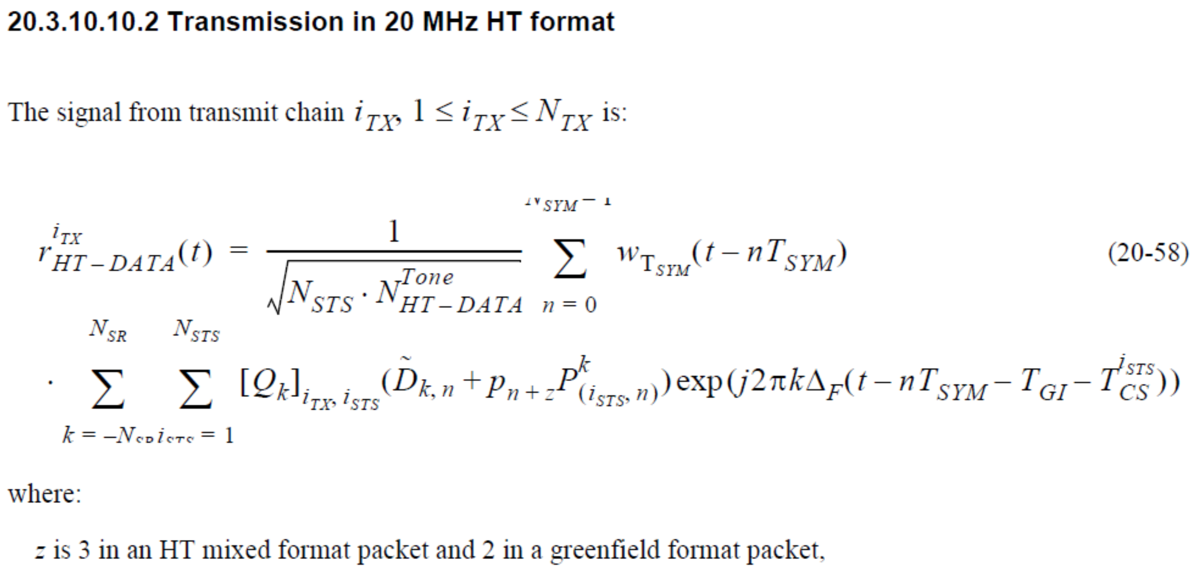
The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field).
The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2).

…



$$D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$$

See, e.g., 802.11n D2.0 § 20.3.9.4.3



20.3.10.10.2 Transmission in 20 MHz HT format

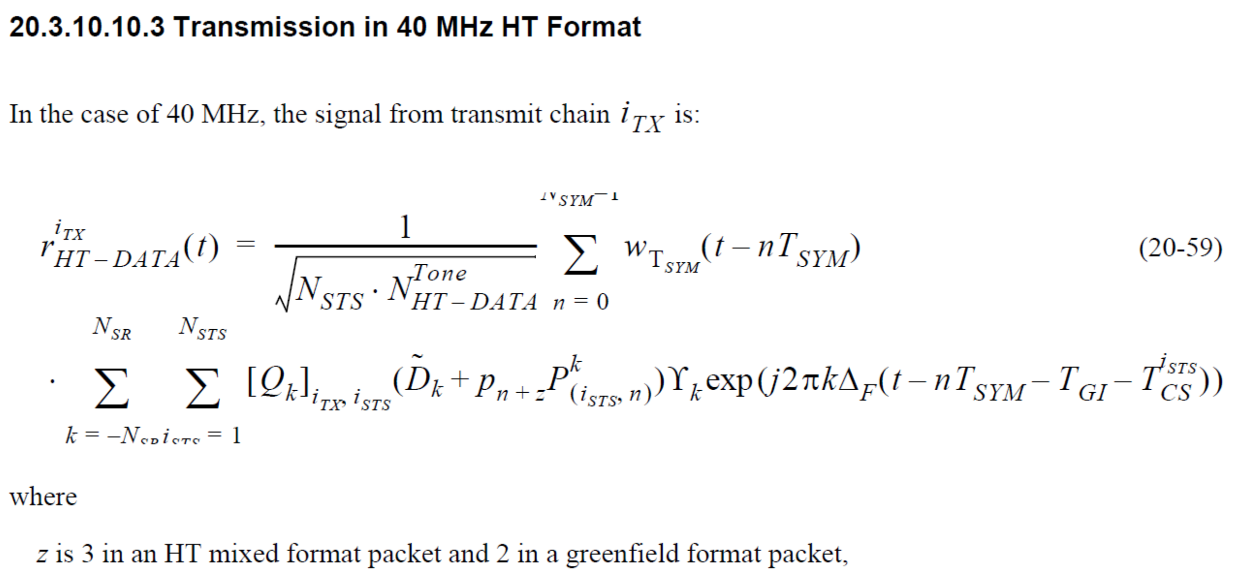
The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is:

$$r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P^k_{(i_{STS},n)}) \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}})) \quad (20\text{-}58)$$

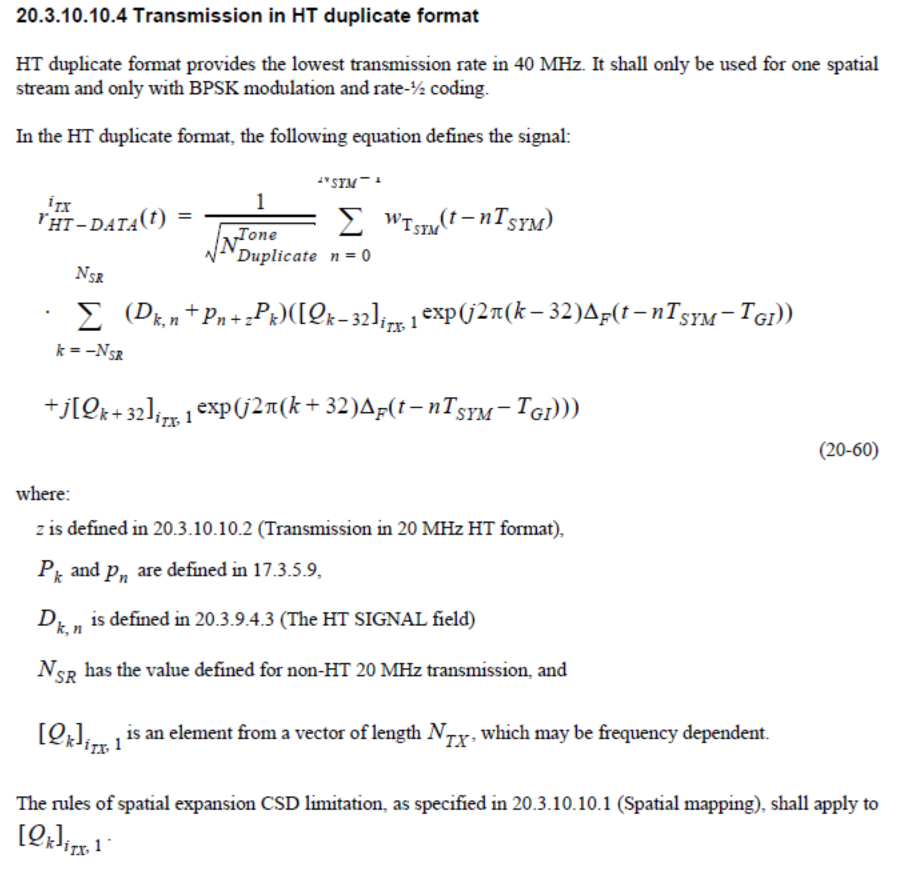
where:

z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

</td></tr>
</table>

Claim 1 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS} \cdot N^{Tone}_{HT-DATA}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P^k_{(i_{STS}, n)}) \Upsilon_k \exp(j2\pi k\Delta_F(t - nT_{SYM} - T_{GI} - T^{i_{STS}}_{CS}))$ (20-59) where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

<table>
<tr><th>Claim 1 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>



20.3.10.10.4 Transmission in HT duplicate format

HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding.

In the HT duplicate format, the following equation defines the signal:

$$r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n}+p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI})) + j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}))) \qquad (20\text{-}60)$$

where:

z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format),

P_k and p_n are defined in 17.3.5.9,

$D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field)

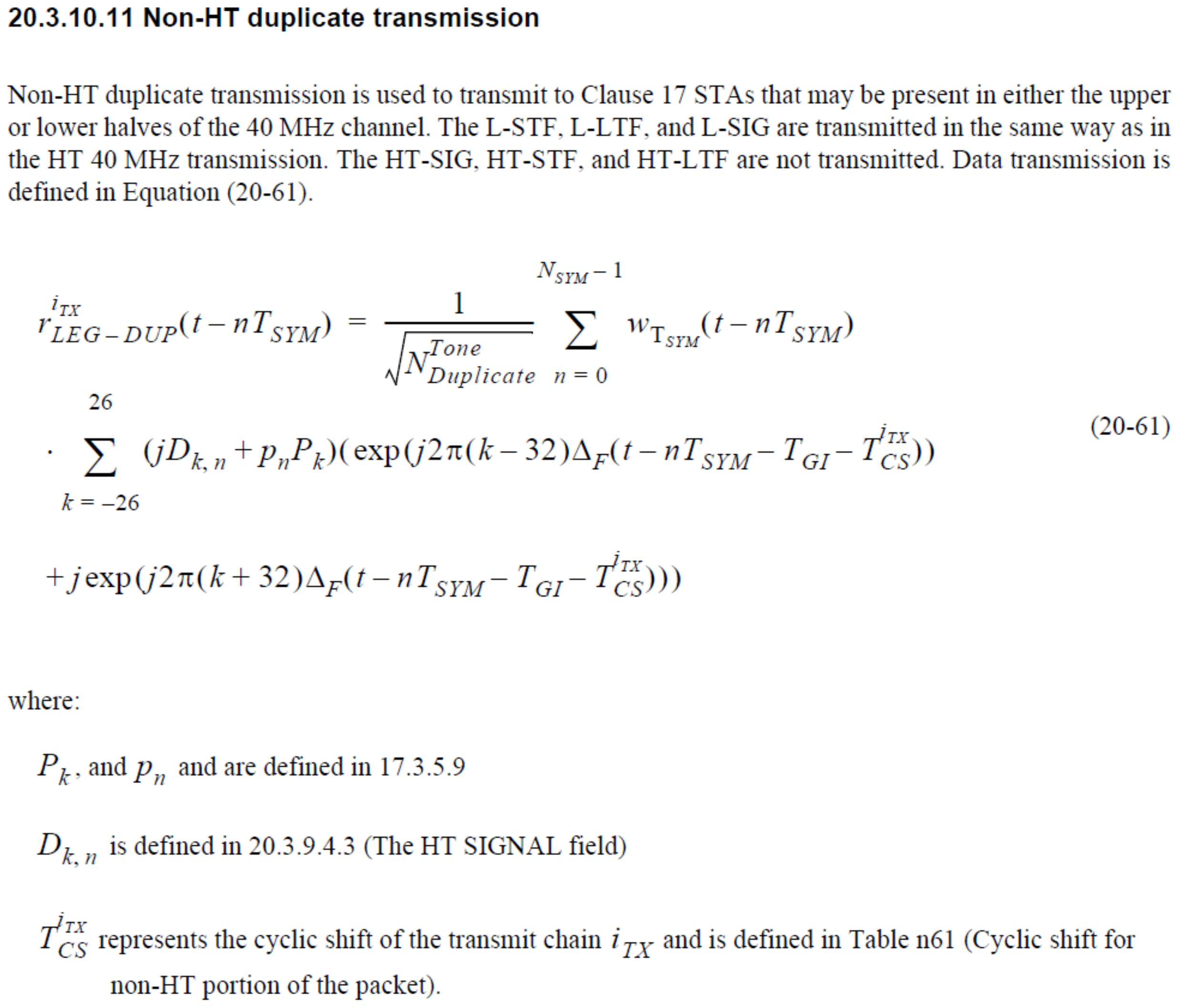
N_{SR} has the value defined for non-HT 20 MHz transmission, and

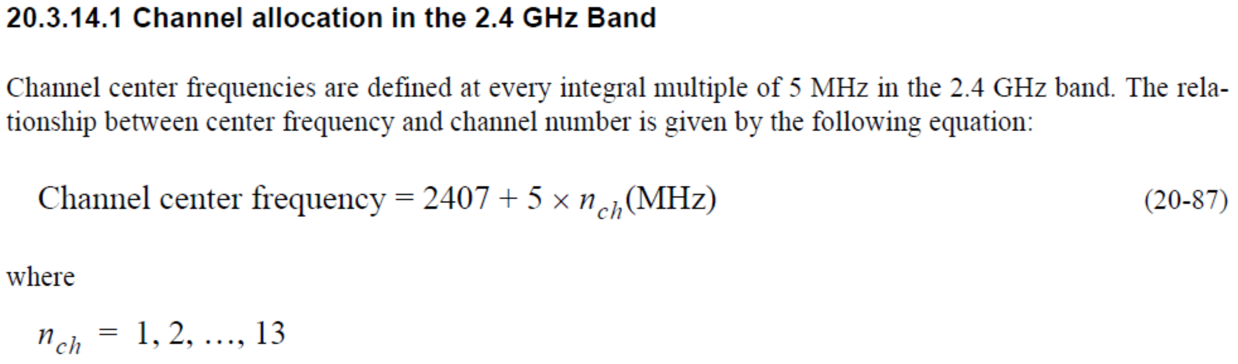
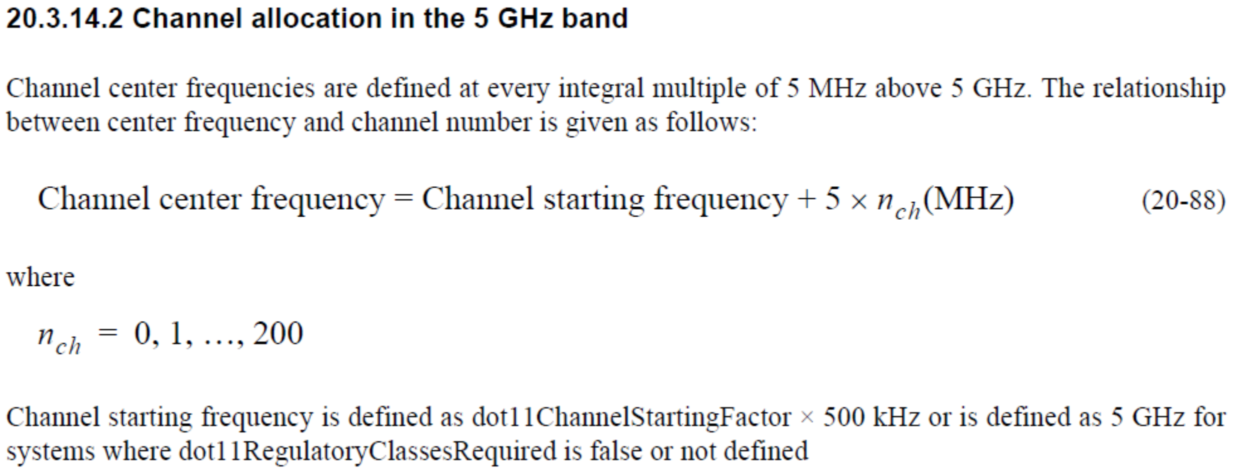
$[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent.

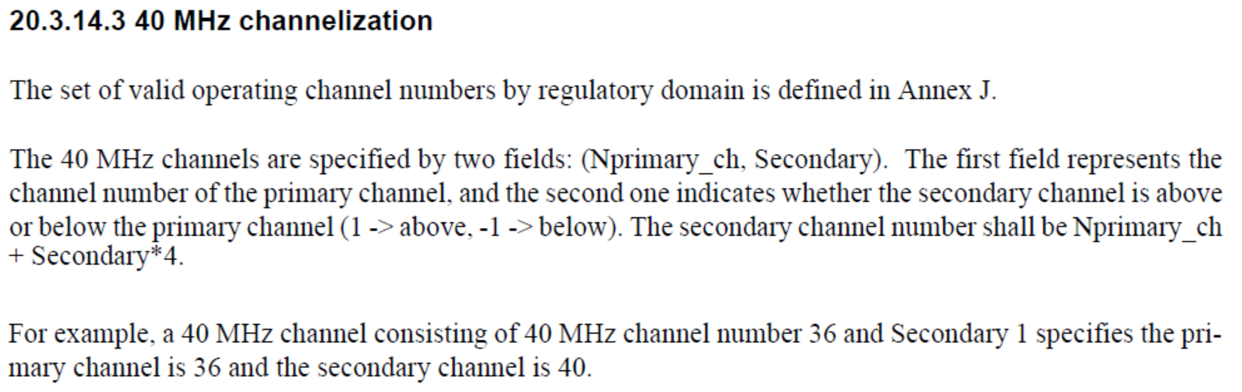
The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$.

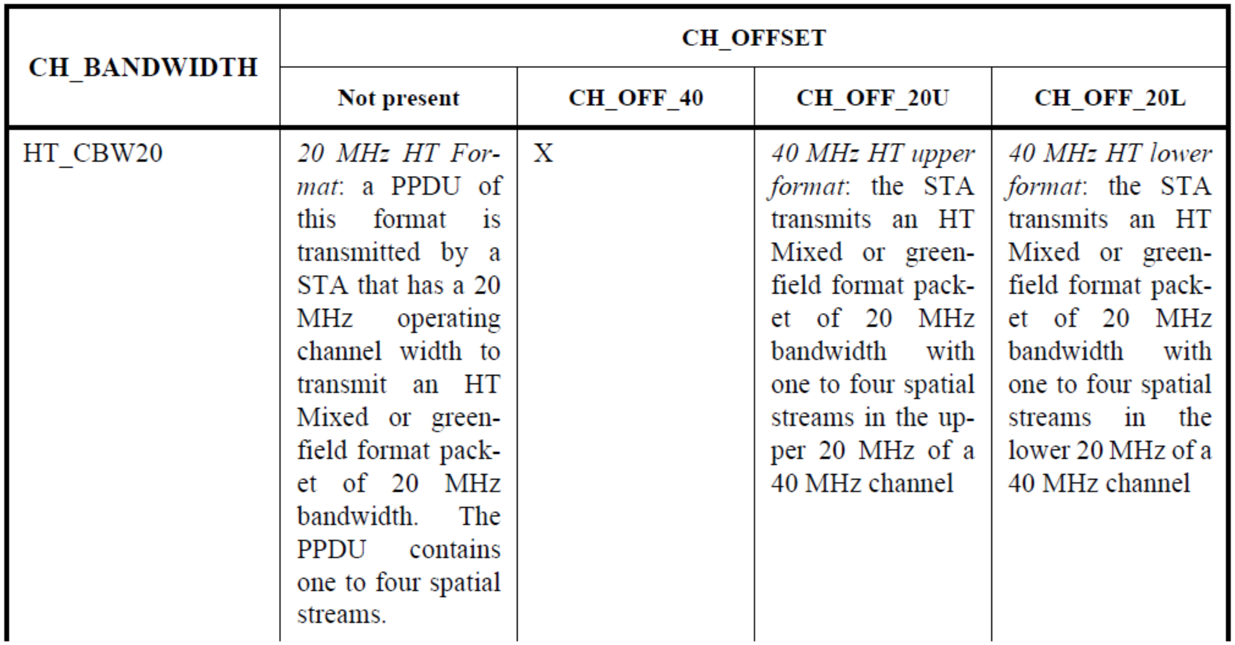
See, e.g., 802.11n D2.0 § 20.3.10.10.4

</td></tr>
</table>

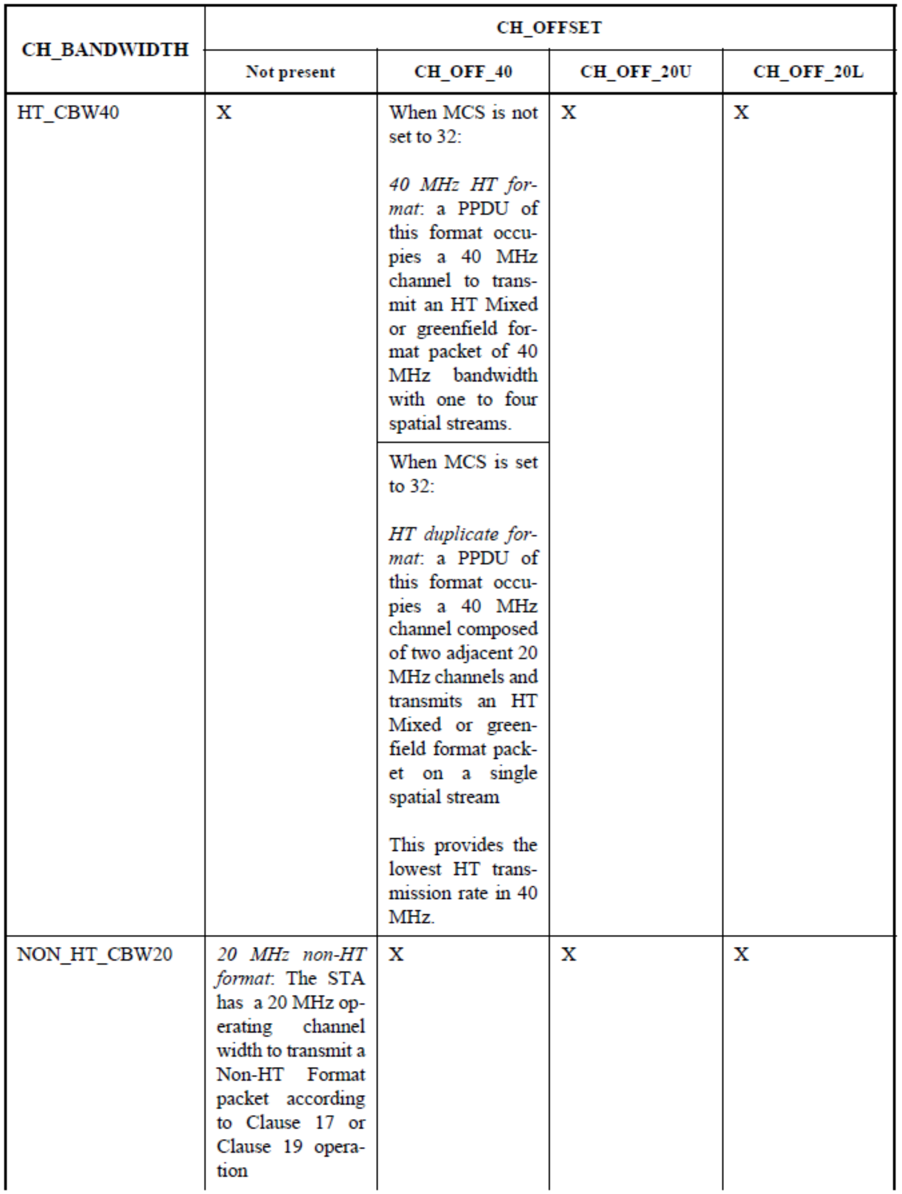
Claim 1 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r_{LEG-DUP}^{i_{TX}}(t-nT_{SYM}) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n}+p_n P_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{TX}})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{TX}})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T_{CS}^{i_{TX}}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 1 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz})$ (20-87) where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz})$ (20-88) where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

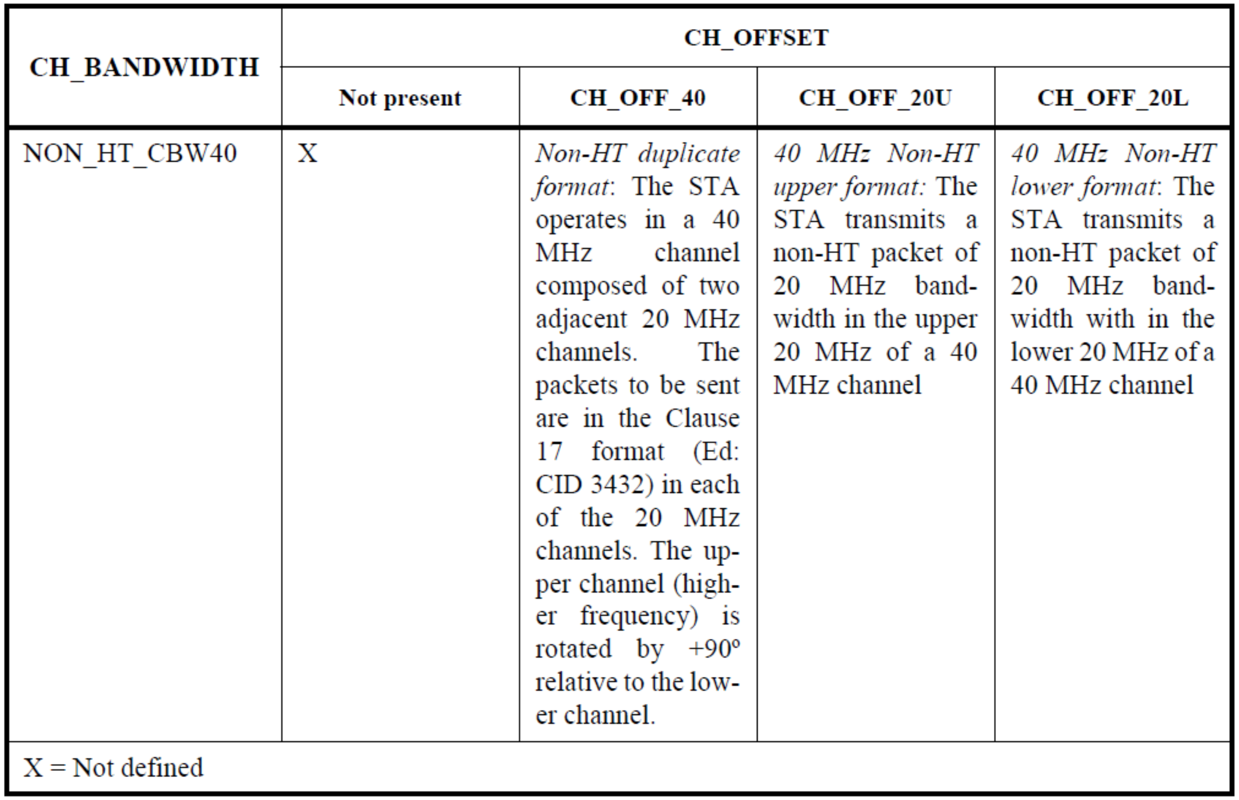
Claim 1 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

Claim 1 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.20.3 **Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters** 

CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or green-field format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or green-field format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or green-field format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel



CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

Claim 1 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 See, e.g., 802.11n D2.0 Table n55

CH_BANDWIDTH	**CH_OFFSET**			
	Not present	**CH_OFF_40**	**CH_OFF_20U**	**CH_OFF_20L**
NON_HT_CBW40	X	*Non-HT duplicate format*: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.	*40 MHz Non-HT upper format:* The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel	*40 MHz Non-HT lower format*: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel
X = Not defined				

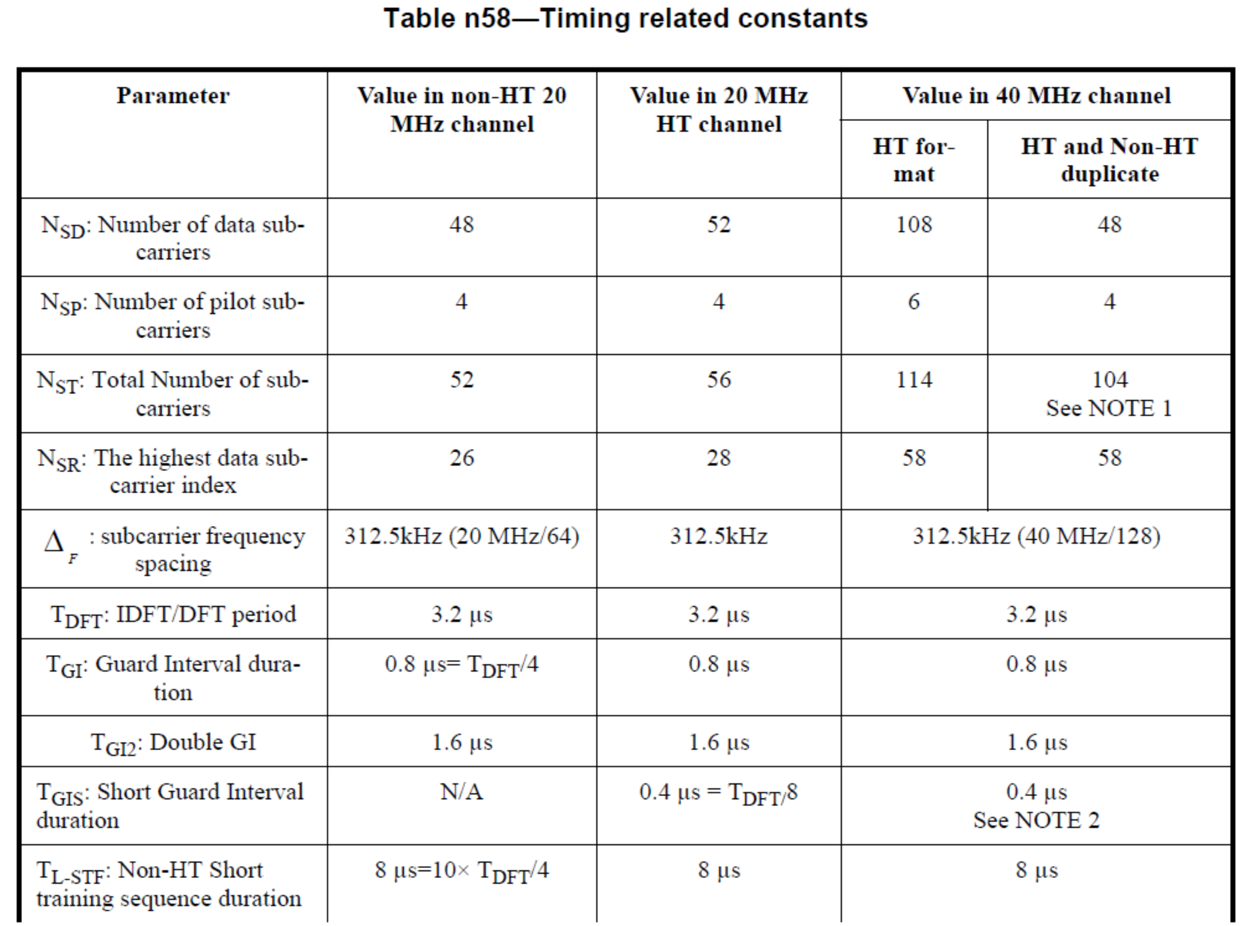
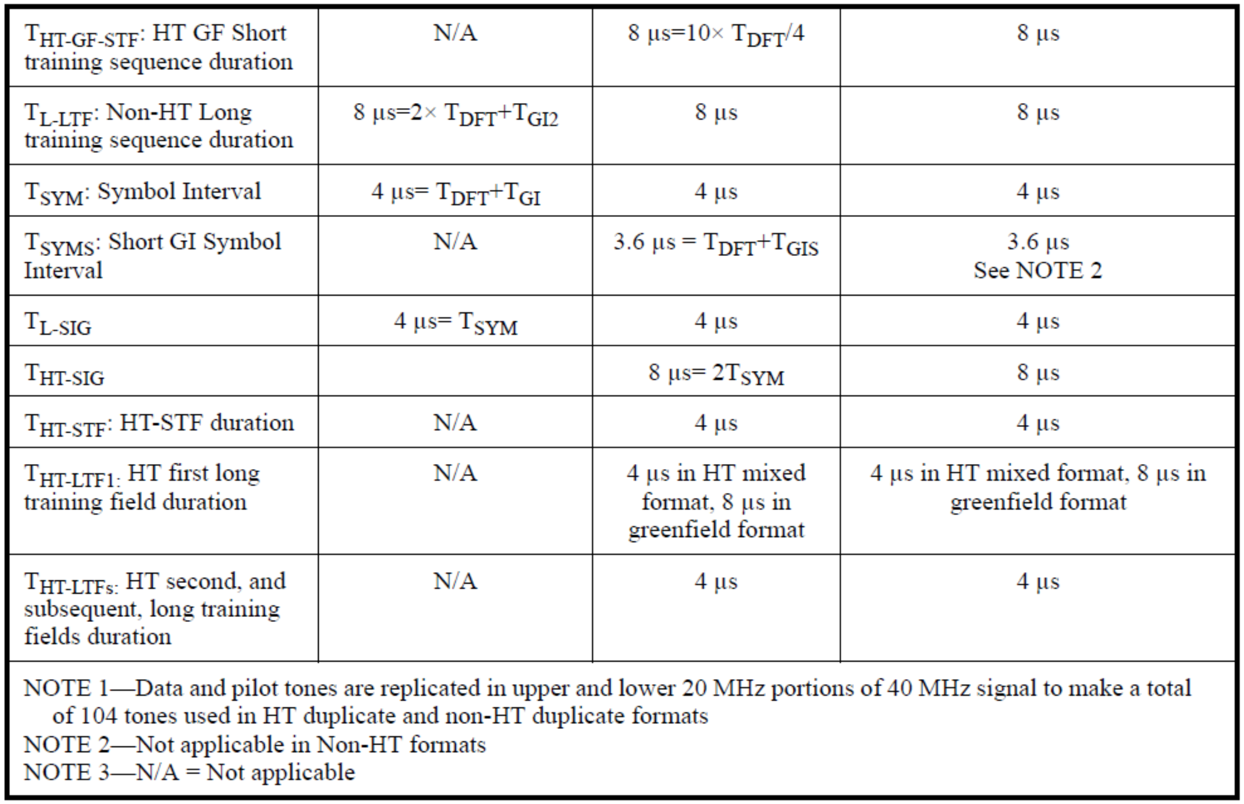
Claim 1 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	

Table n58—Timing related constants

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
T_{L-STF}: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

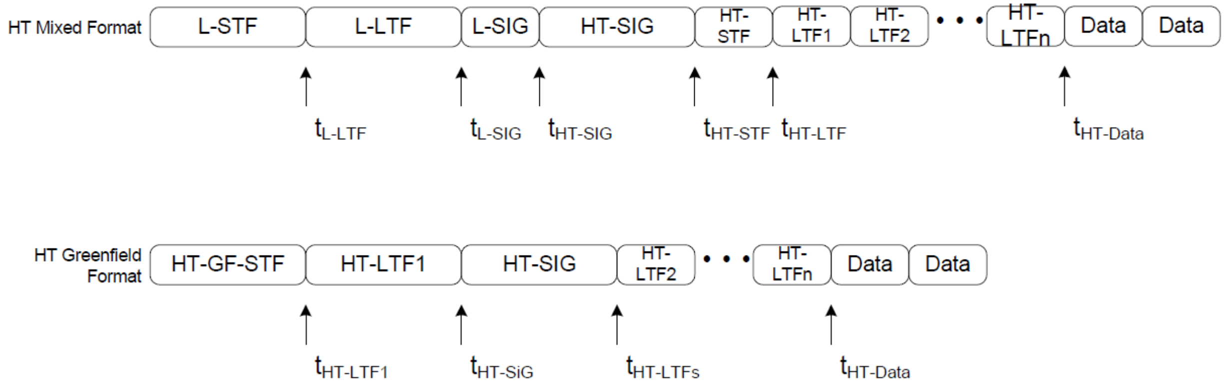
Claim 1 of the ’802 Patent	Prior Art Reference – 802.11n D2.0



$T_{HT\text{-}GF\text{-}STF}$: HT GF Short training sequence duration	N/A	8 μs=10× T_{DFT}/4	8 μs
$T_{L\text{-}LTF}$: Non-HT Long training sequence duration	8 μs=2× $T_{DFT}+T_{GI2}$	8 μs	8 μs
T_{SYM}: Symbol Interval	4 μs= $T_{DFT}+T_{GI}$	4 μs	4 μs
T_{SYMS}: Short GI Symbol Interval	N/A	3.6 μs = $T_{DFT}+T_{GIS}$	3.6 μs See NOTE 2
$T_{L\text{-}SIG}$	4 μs= T_{SYM}	4 μs	4 μs
$T_{HT\text{-}SIG}$		8 μs= 2T_{SYM}	8 μs
$T_{HT\text{-}STF}$: HT-STF duration	N/A	4 μs	4 μs
$T_{HT\text{-}LTF1}$: HT first long training field duration	N/A	4 μs in HT mixed format, 8 μs in greenfield format	4 μs in HT mixed format, 8 μs in greenfield format
$T_{HT\text{-}LTFs}$: HT second, and subsequent, long training fields duration	N/A	4 μs	4 μs

NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable

See, e.g., 802.11n D2.0 Table n58

Claim 1 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.
[1.3] simultaneously transmitting second information across a second frequency range using the same wireless transmitter, the second frequency range having a second center frequency greater than the	802.11n D2.0 discloses “simultaneously transmitting second information across a second frequency range using the same wireless transmitter, the second frequency range having a second center frequency greater than the first center frequency, a second highest frequency, and a second lowest frequency.” See, e.g.: **high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19

Claim 1 of the '802 Patent	Prior Art Reference – 802.11n D2.0
first center frequency, a second highest frequency, and a second lowest frequency.	**non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

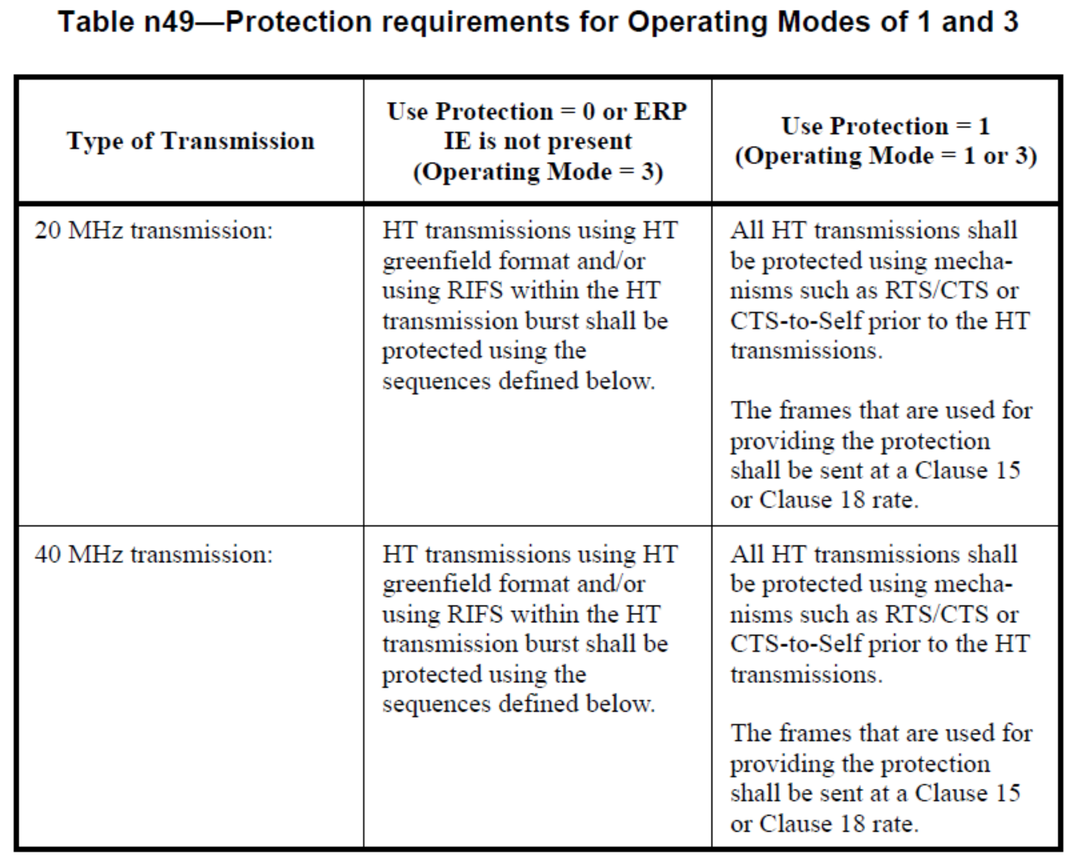
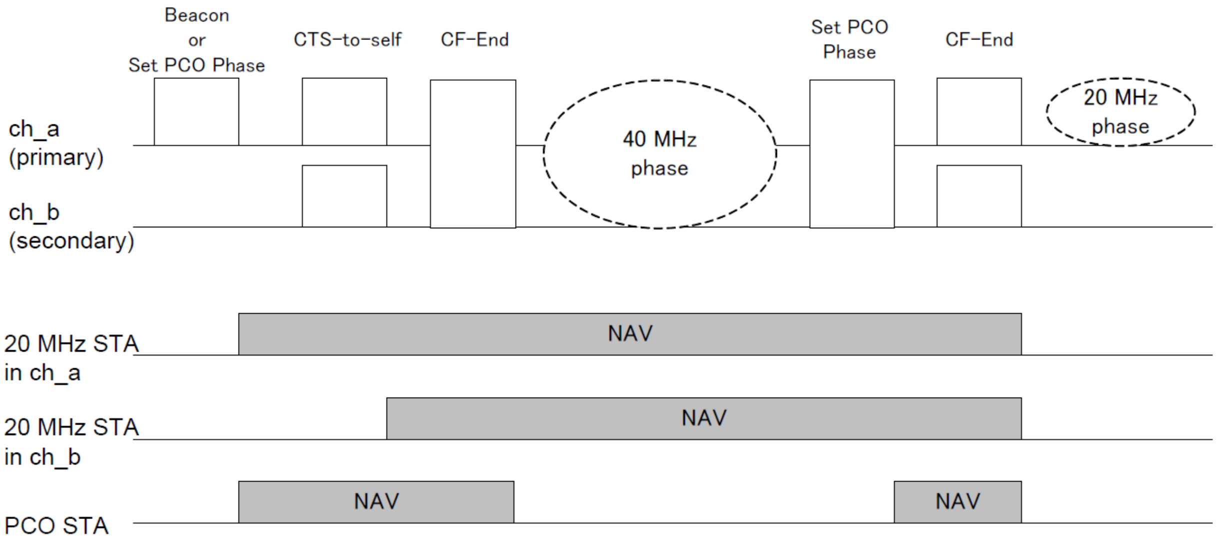
<table>
<tr><th>Claim 1 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>


Table n49—Protection requirements for Operating Modes of 1 and 3

<table>
<tr><th>Type of Transmission</th><th>Use Protection = 0 or ERP IE is not present (Operating Mode = 3)</th><th>Use Protection = 1 (Operating Mode = 1 or 3)</th></tr>
<tr><td>20 MHz transmission:</td><td>HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.</td><td>All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions.
The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.</td></tr>
<tr><td>40 MHz transmission:</td><td>HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.</td><td>All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions.
The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.</td></tr>
</table>

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.
NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).
</td></tr>
</table>

Claim 1 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

Claim 1 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

Claim 1 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format*: packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format*: packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format*: HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 1 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

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	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

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	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

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	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t \right) \right\}$ (20-1) where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

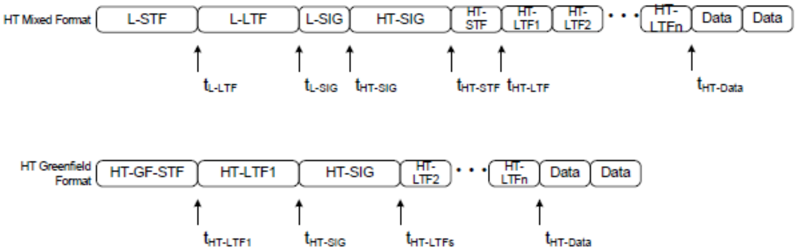

Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field}, determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) \; = \; & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right) T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \tag{20-2}$$

where

$$t_{L-LTF} = T_{L-STF}$$

$$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$$

$$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$$

$$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1}) \\ & + r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2) T_{HT-LTFs}) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \qquad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\text{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\text{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j 2\pi k \Delta_F t) \qquad (20\text{-}4)$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \qquad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \qquad (20\text{-}6)$$

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	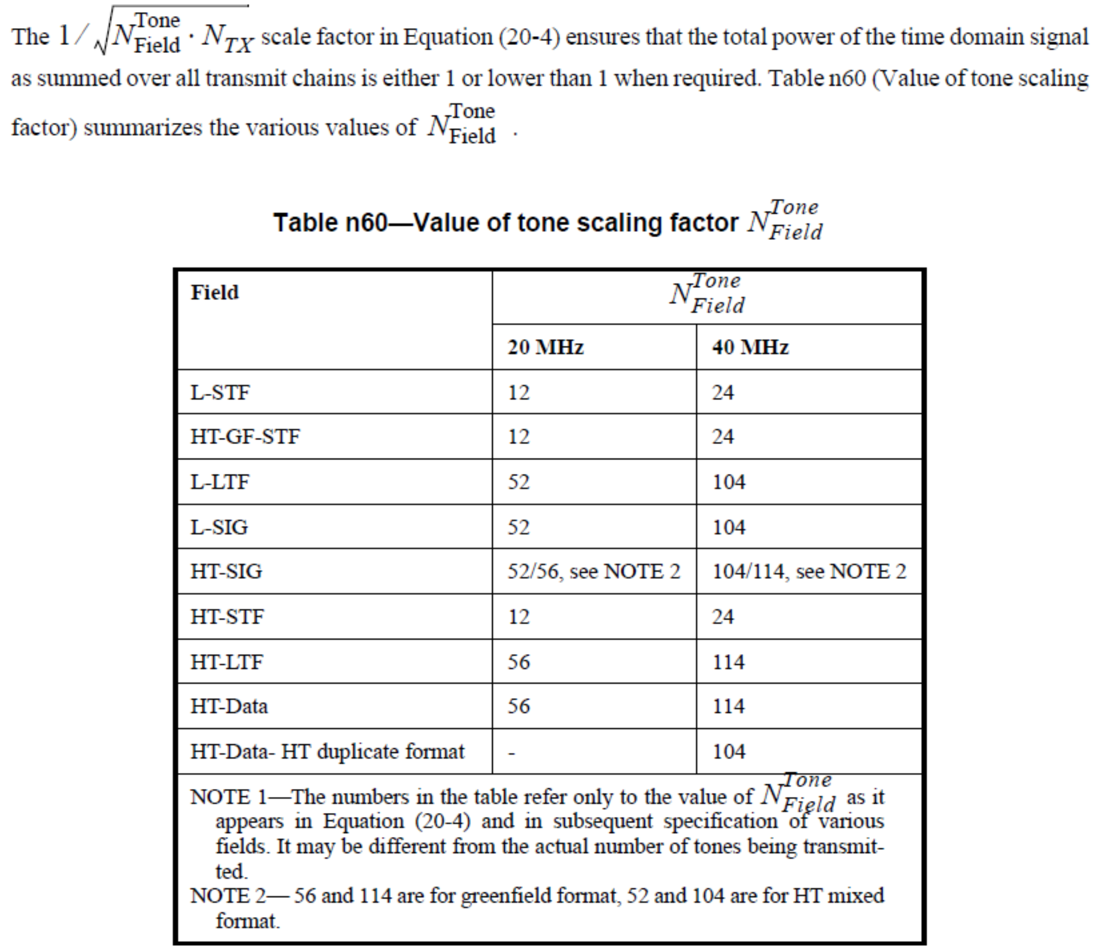 The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$. **Table n60—Value of tone scaling factor N_{Field}^{Tone}** See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65 **20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel** When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

Field	N_{Field}^{Tone}	
	20 MHz	**40 MHz**
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

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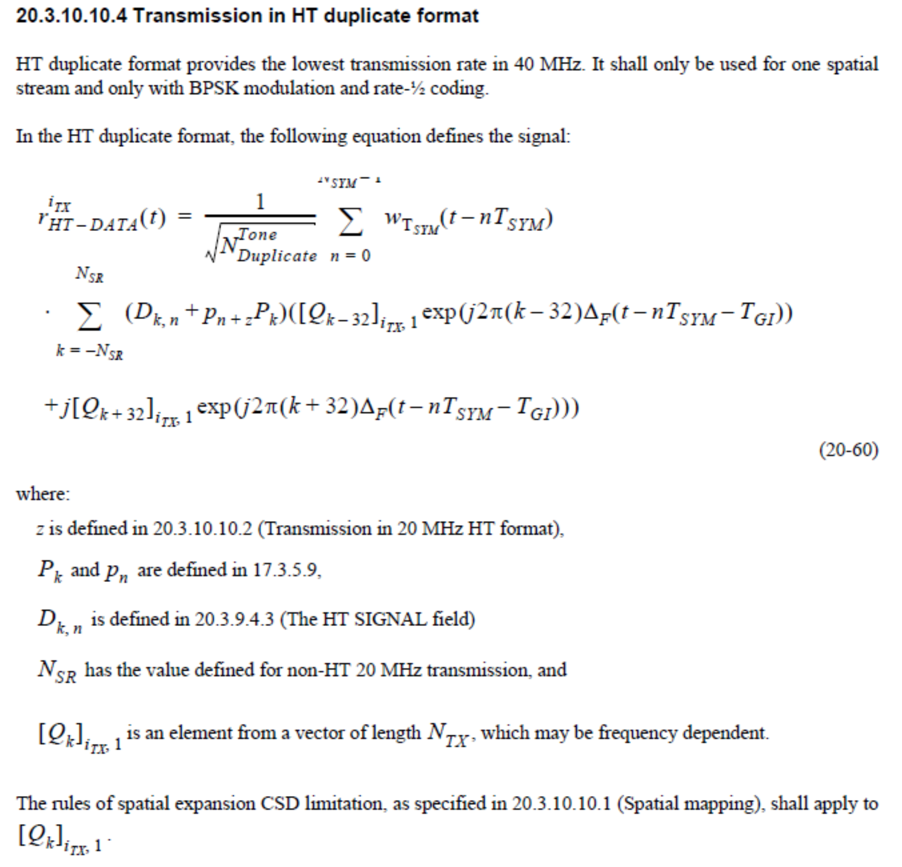
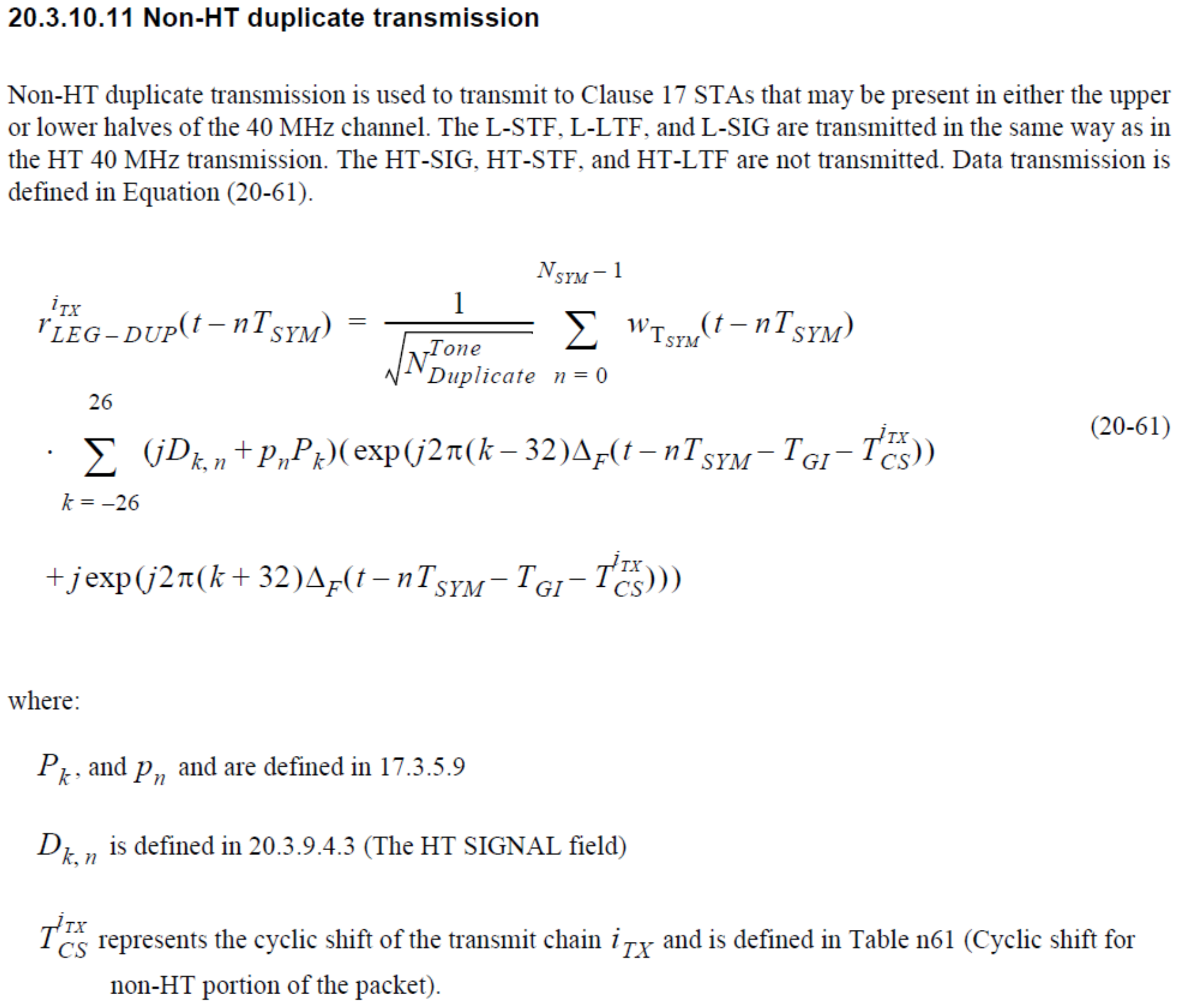
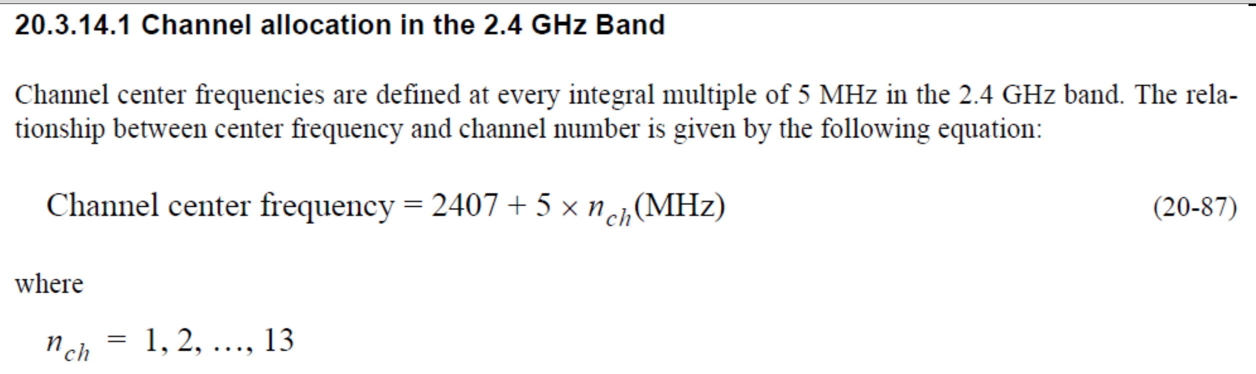
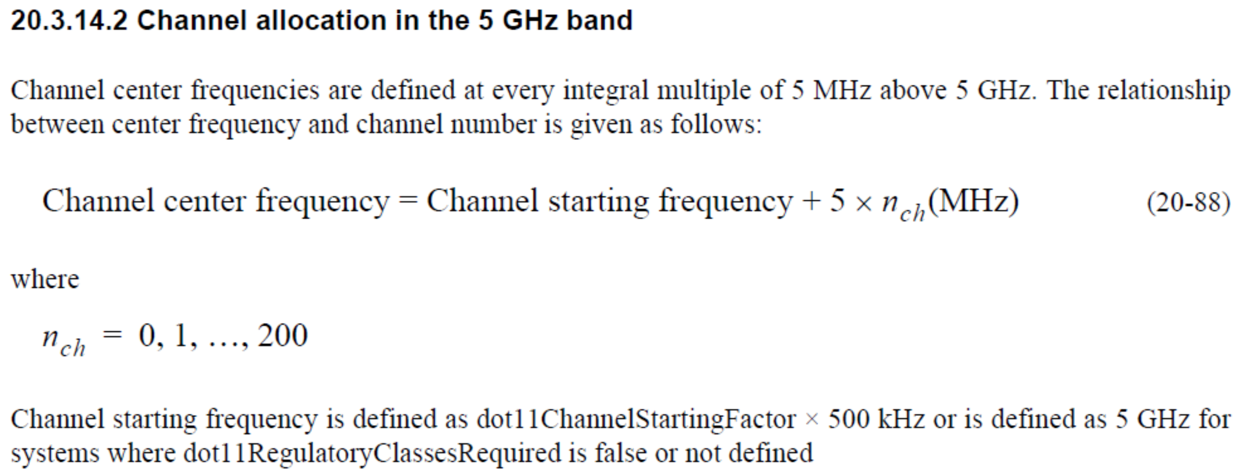
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM})$ (20-58) $\cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P_{(i_{STS},n)}^{k}) \exp(j 2 \pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

Claim 1 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.10.10.2 **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P_{(i_{STS}, n)}^{k}) \Upsilon_k \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (20-59) where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

Claim 1 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n}+p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI})) + j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

Claim 1 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r_{LEG-DUP}^{i_{TX}}(t - nT_{SYM}) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n} + p_n P_k)(\exp(j2\pi(k-32)\Delta_F(t - nT_{SYM} - T_{GI} - T_{CS}^{i_{TX}})) + j\exp(j2\pi(k+32)\Delta_F(t - nT_{SYM} - T_{GI} - T_{CS}^{i_{TX}})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T_{CS}^{i_{TX}}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 1 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz})$ (20-87) where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz})$ (20-88) where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 1 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	20.3.14.3 40 MHz channelization The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

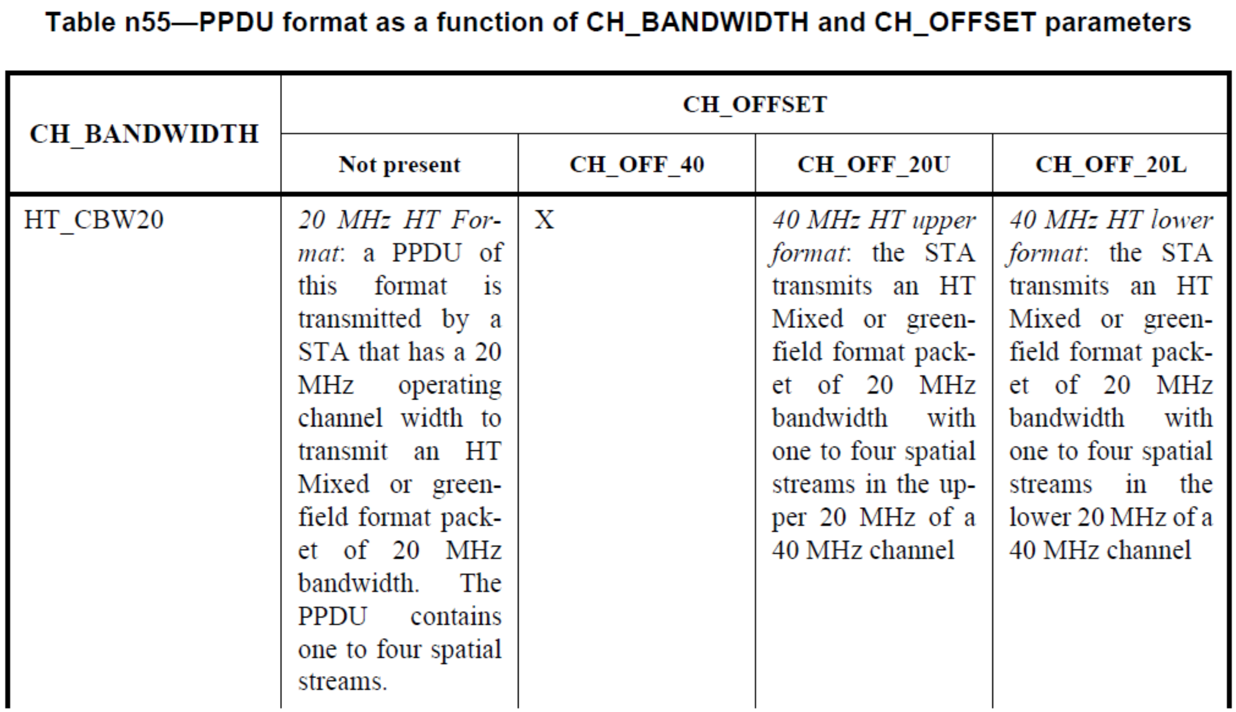
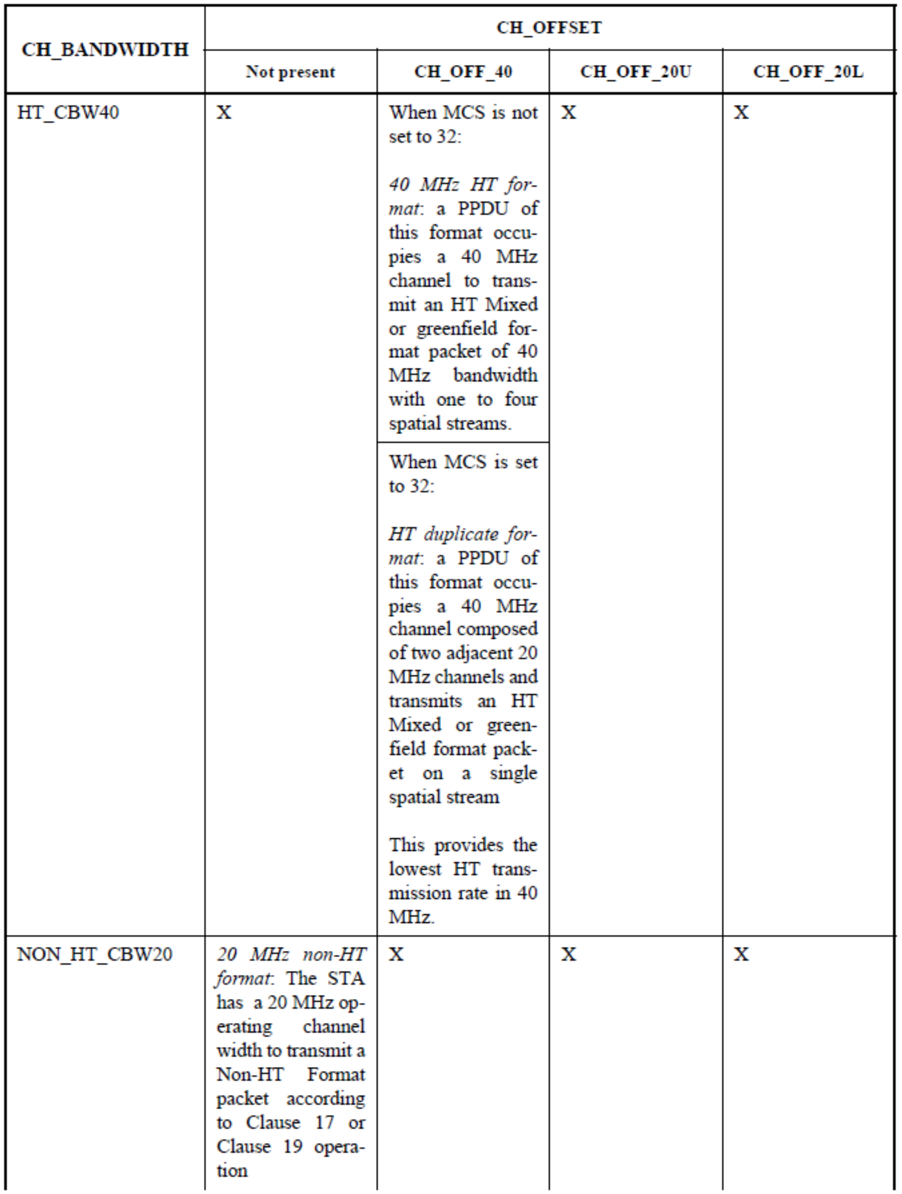
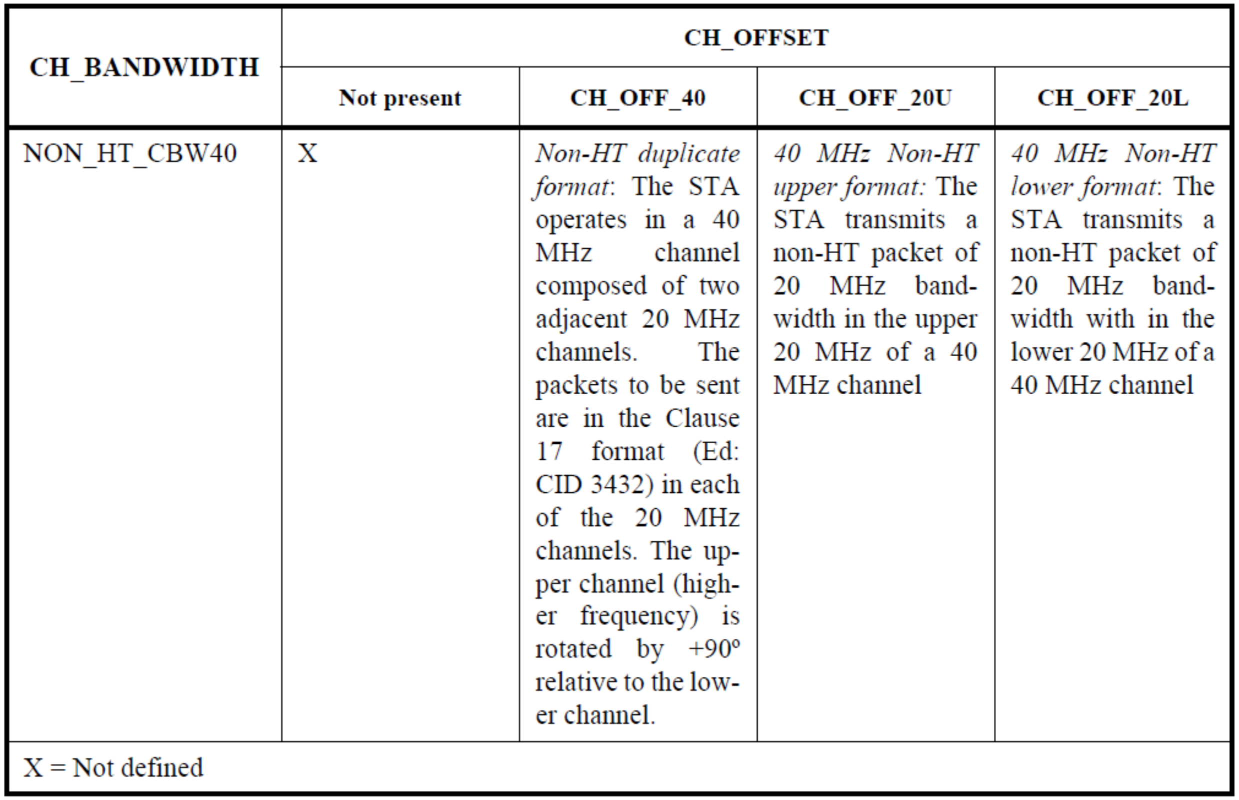
Claim 1 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.20.3 

Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

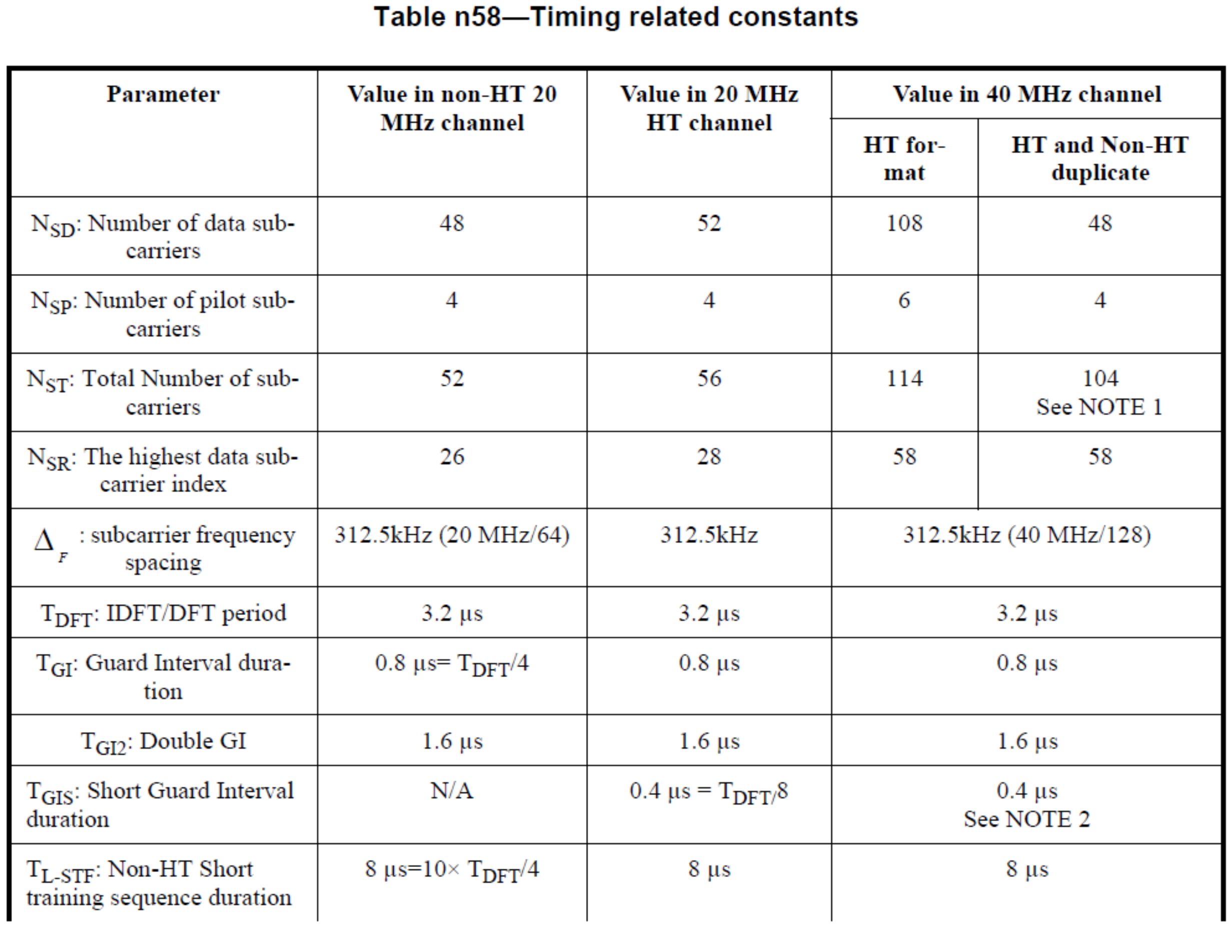
CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel



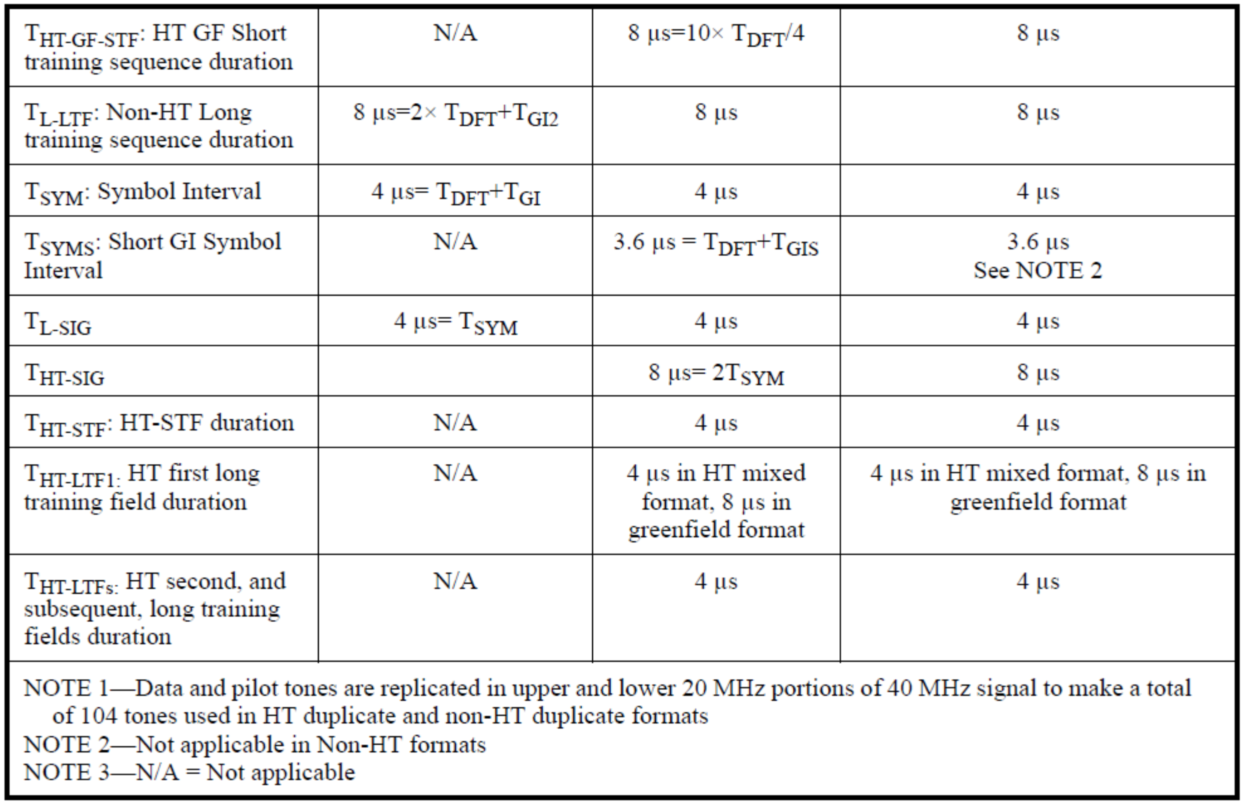
CH_BANDWIDTH	**CH_OFFSET**			
	Not present	**CH_OFF_40**	**CH_OFF_20U**	**CH_OFF_20L**
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

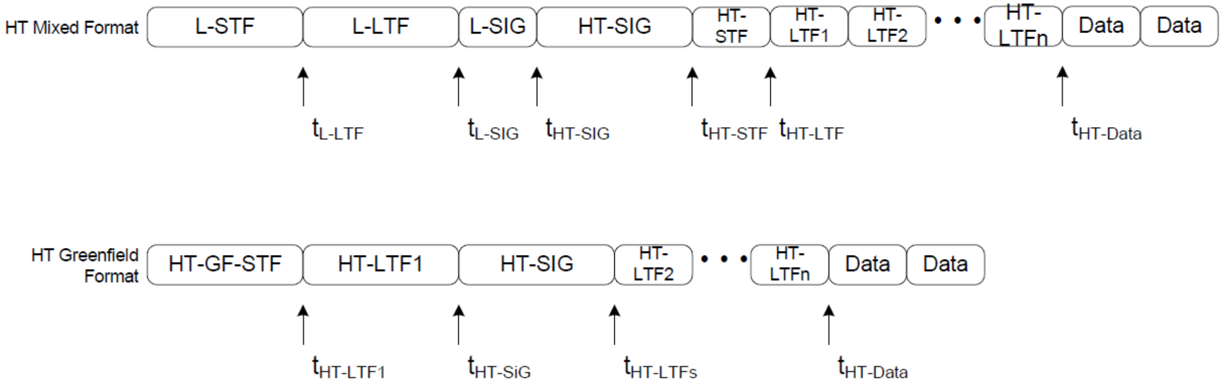
<table>
<tr><th>Claim 1 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>NON_HT_CBW40</td><td>X</td><td><i>Non-HT duplicate format</i>: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.</td><td><i>40 MHz Non-HT upper format:</i> The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel</td><td><i>40 MHz Non-HT lower format</i>: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel</td></tr>
<tr><td colspan="5">X = Not defined</td></tr>
</table>

See, e.g., 802.11n D2.0 Table n55
</td></tr>
</table>

Claim 1 of the '802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **Table n58—Timing related constants**

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

<table>
<tr><th>Claim 1 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><td>$T_{HT-GF-STF}$: HT GF Short training sequence duration</td><td>N/A</td><td>8 μs=10× $T_{DFT}/4$</td><td>8 μs</td></tr>
<tr><td>T_{L-LTF}: Non-HT Long training sequence duration</td><td>8 μs=2× $T_{DFT}+T_{GI2}$</td><td>8 μs</td><td>8 μs</td></tr>
<tr><td>T_{SYM}: Symbol Interval</td><td>4 μs= $T_{DFT}+T_{GI}$</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td>T_{SYMS}: Short GI Symbol Interval</td><td>N/A</td><td>3.6 μs = $T_{DFT}+T_{GIS}$</td><td>3.6 μs
See NOTE 2</td></tr>
<tr><td>T_{L-SIG}</td><td>4 μs= T_{SYM}</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td>T_{HT-SIG}</td><td></td><td>8 μs= 2T_{SYM}</td><td>8 μs</td></tr>
<tr><td>T_{HT-STF}: HT-STF duration</td><td>N/A</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td>$T_{HT-LTF1}$: HT first long training field duration</td><td>N/A</td><td>4 μs in HT mixed format, 8 μs in greenfield format</td><td>4 μs in HT mixed format, 8 μs in greenfield format</td></tr>
<tr><td>$T_{HT-LTFs}$: HT second, and subsequent, long training fields duration</td><td>N/A</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td colspan="4">NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n58
</td></tr>
</table>

Claim 1 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.

Claim 2 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
[2.1] The method of claim 1	802.11n D2.0 discloses all the elements of claim 1 for all the reasons provided above.
[2.2] wherein frequency difference between the first center frequency and the	802.11n D2.0 discloses “wherein frequency difference between the first center frequency and the second center frequency is greater than the sum of one-half the first frequency range and one-half the second frequency range.” See, e.g.:

Claim 2 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
second center frequency is greater than the sum of one-half the first frequency range and one-half the second frequency range.	**high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19 **non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

Claim 2 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**

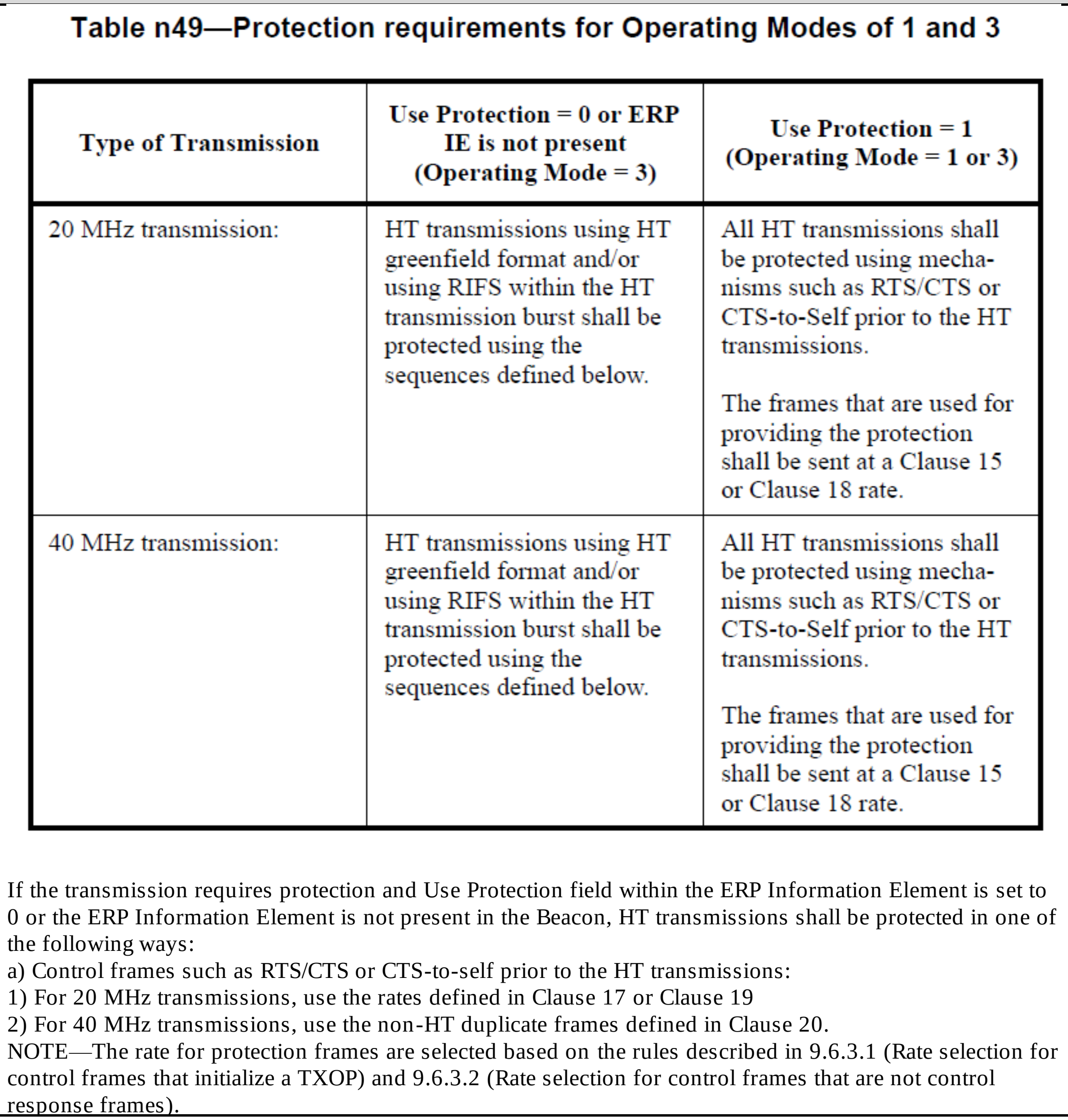
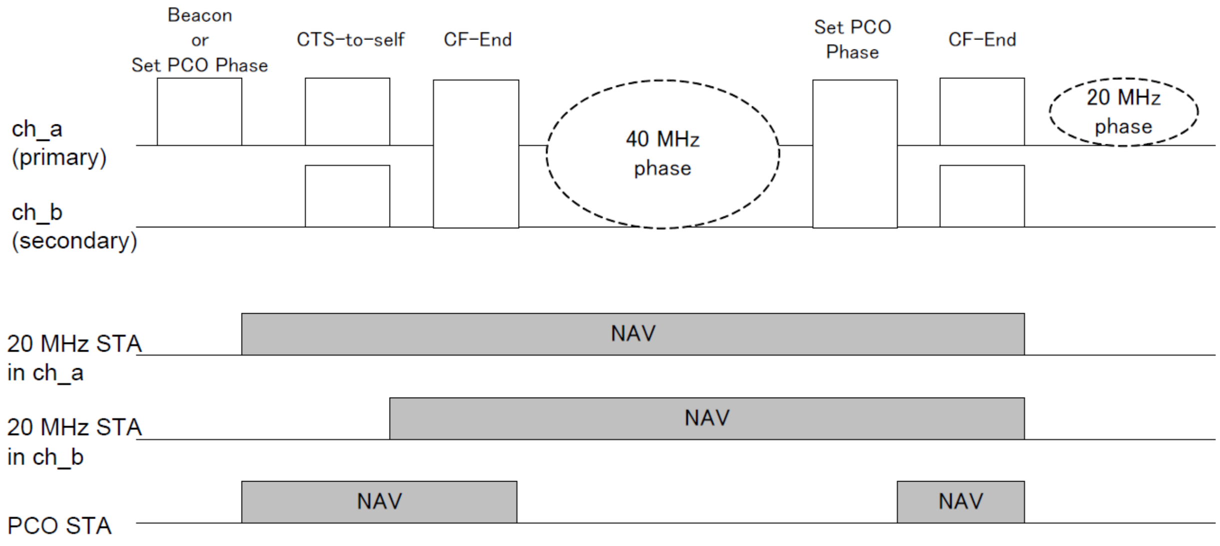


Table n49—Protection requirements for Operating Modes of 1 and 3

Type of Transmission	Use Protection = 0 or ERP IE is not present (Operating Mode = 3)	Use Protection = 1 (Operating Mode = 1 or 3)
20 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.
40 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.
NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).

Claim 2 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

Claim 2 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

Claim 2 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 2 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

Claim 2 of the '802 Patent	**Prior Art Reference – 802.11n D2.0**
	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

Claim 2 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

Claim 2 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t \right) \right\}$ (20-1) where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

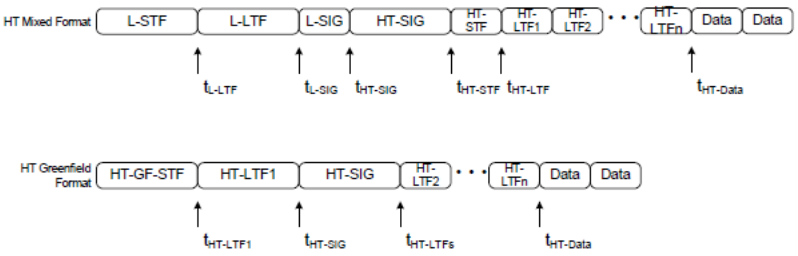


Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right)T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}\left(t - t_{HT-DATA}\right) \end{aligned} \tag{20-2}$$

where

$t_{L-LTF} = T_{L-STF}$

$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$

$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$

$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r^{(i_{TX})}_{PPDU}(t) = {} & r^{(i_{TX})}_{HT-GF-STF}(t) + r^{(i_{TX})}_{HT-LTF1}(t - t_{HT-LTF1}) \\ & + r^{(i_{TX})}_{HT-SIG}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r^{(i_{TX}, i_{LTF})}_{HT-LTF}(t - t_{HT-LTFs} - (i_{LTF} - 2) T_{HT-LTFs}) \\ & + r^{(i_{TX})}_{HT-DATA}(t - t_{HT-DATA}) \end{aligned} \tag{20-3}$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r^{(i_{TX})}_{\mathrm{Field}}(t)$, is defined via the discrete Fourier transform as

$$r^{(i_{TX})}_{\mathrm{Field}}(t) = \frac{1}{\sqrt{N^{\mathrm{Tone}}_{\mathrm{Field}} \cdot N_{TX}}} w_{T_{\mathrm{Field}}}(t) \sum_{k} \Upsilon_k X^{(i_{TX})}_k \exp(j 2\pi k \Delta_F t) \tag{20-4}$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\mathrm{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X^{(i_{TX})}_k$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \tag{20-5}$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \tag{20-6}$$

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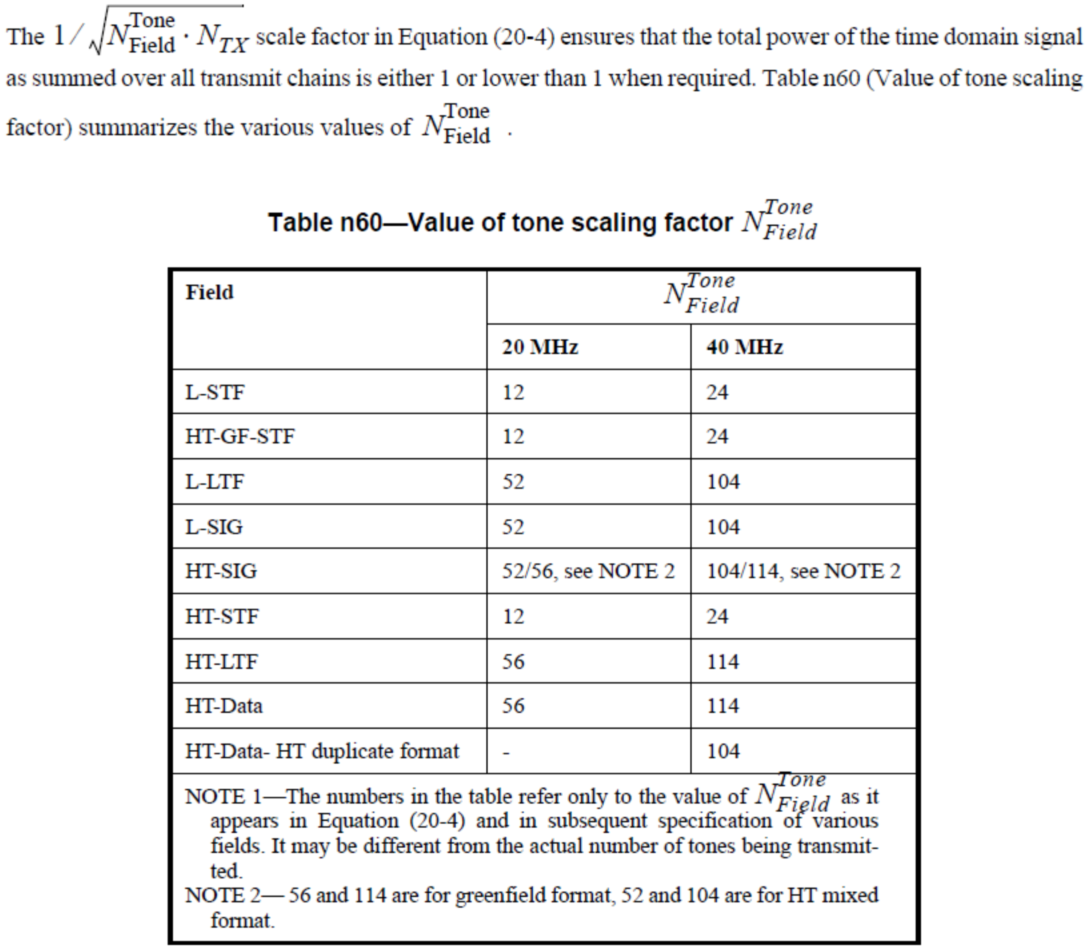


The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	**40 MHz**
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

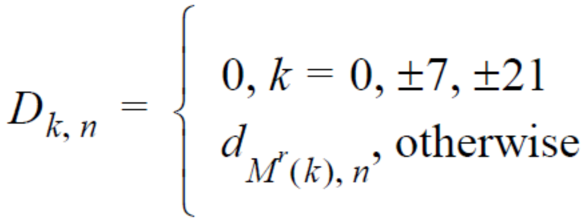
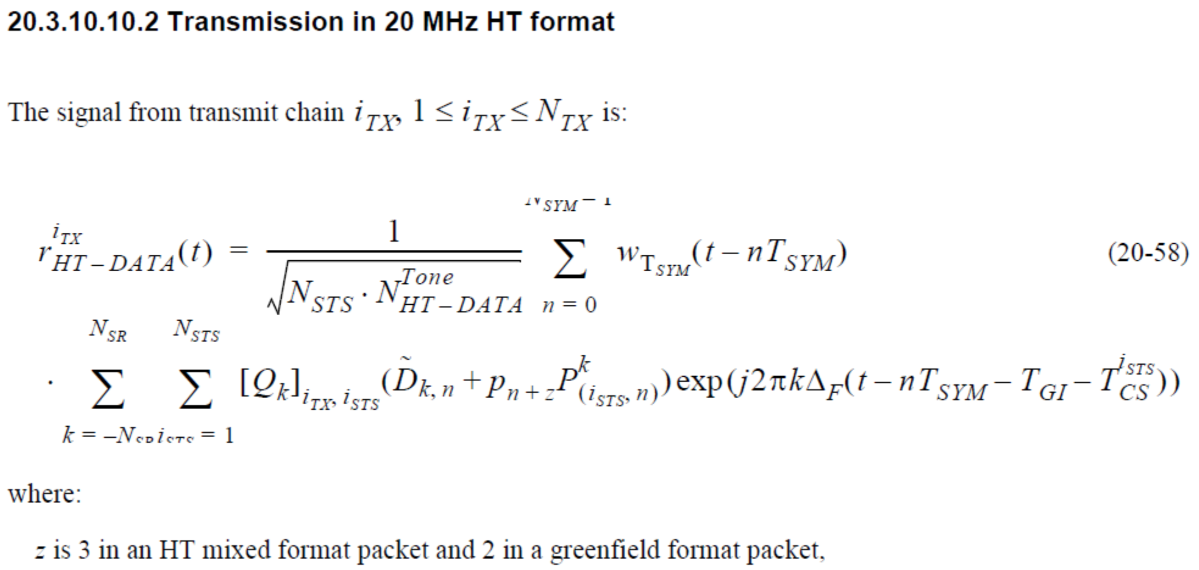
NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

Claim 2 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS} \cdot N^{Tone}_{HT-DATA}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P^k_{(i_{STS}, n)}) \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T^{i_{STS}}_{CS}))$ (20-58) where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

Claim 2 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.10.10.2 **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P_{(i_{STS}, n)}^{k}) \Upsilon_k \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (20-59) where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

<table>
<tr><th>Claim 2 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
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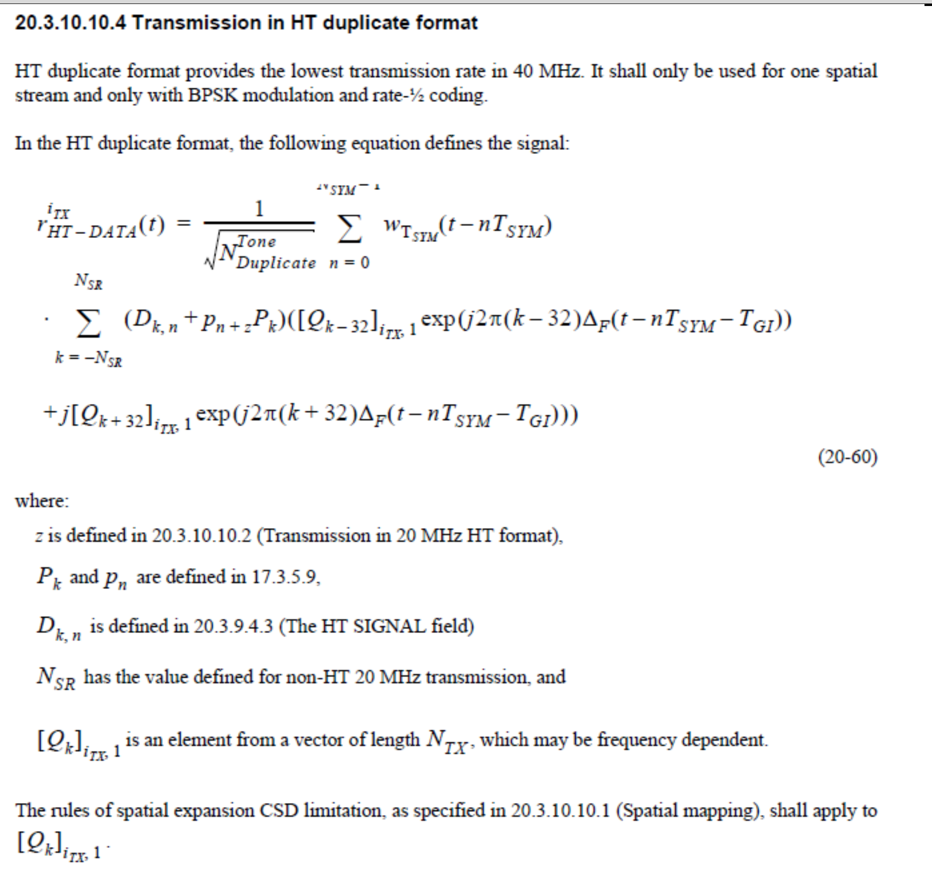

20.3.10.10.4 Transmission in HT duplicate format

HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding.

In the HT duplicate format, the following equation defines the signal:

$$r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n}+p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1}\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI})) + j[Q_{k+32}]_{i_{TX},1}\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}))) \quad (20\text{-}60)$$

where:

z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format),

P_k and p_n are defined in 17.3.5.9,

$D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field)

N_{SR} has the value defined for non-HT 20 MHz transmission, and

$[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent.

The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$.

See, e.g., 802.11n D2.0 § 20.3.10.10.4
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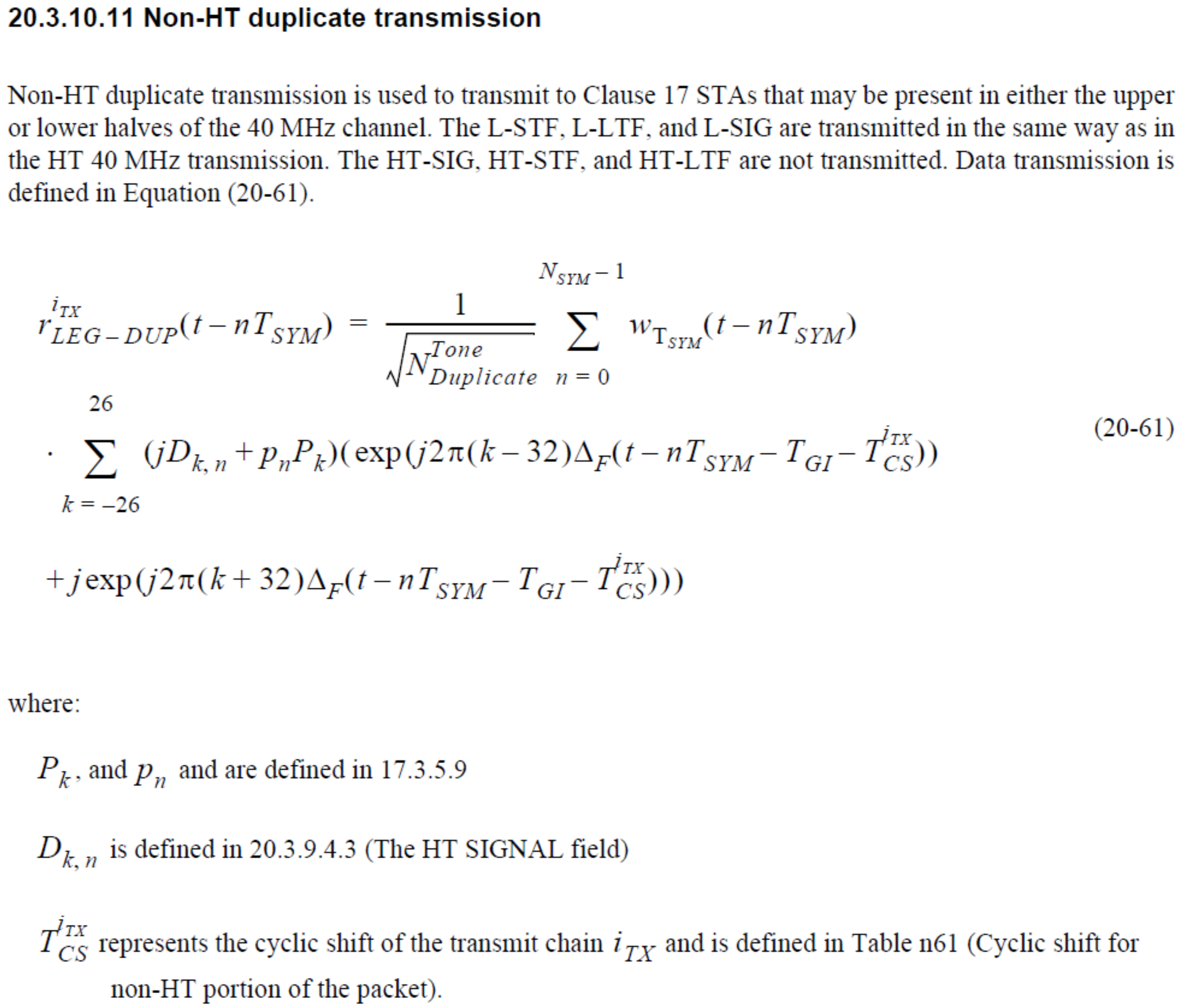
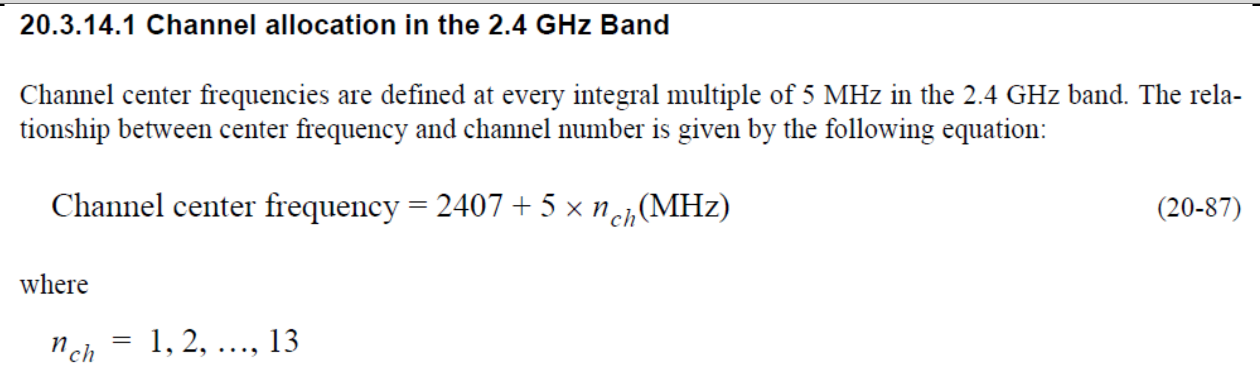
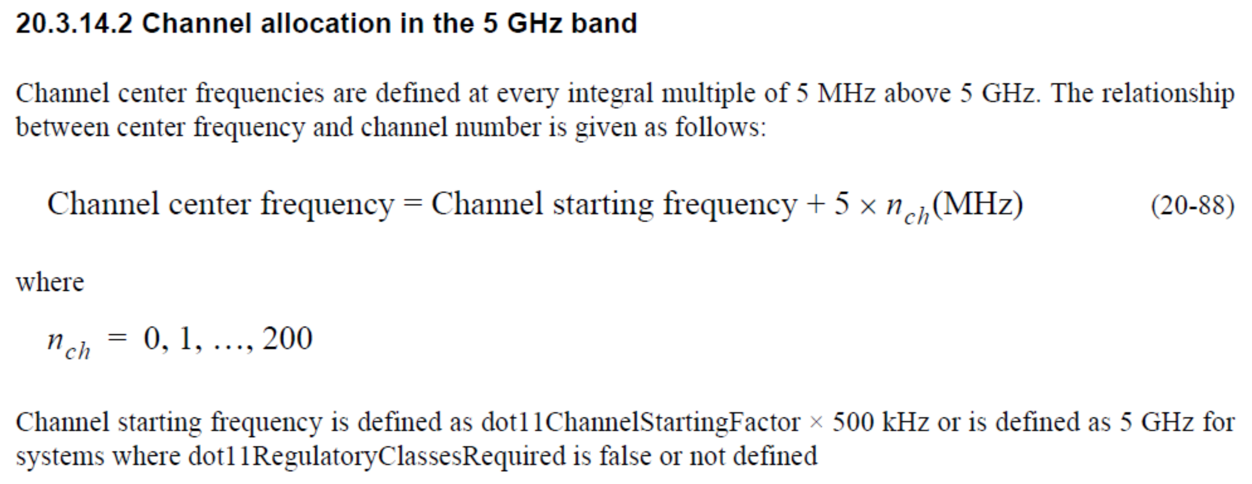
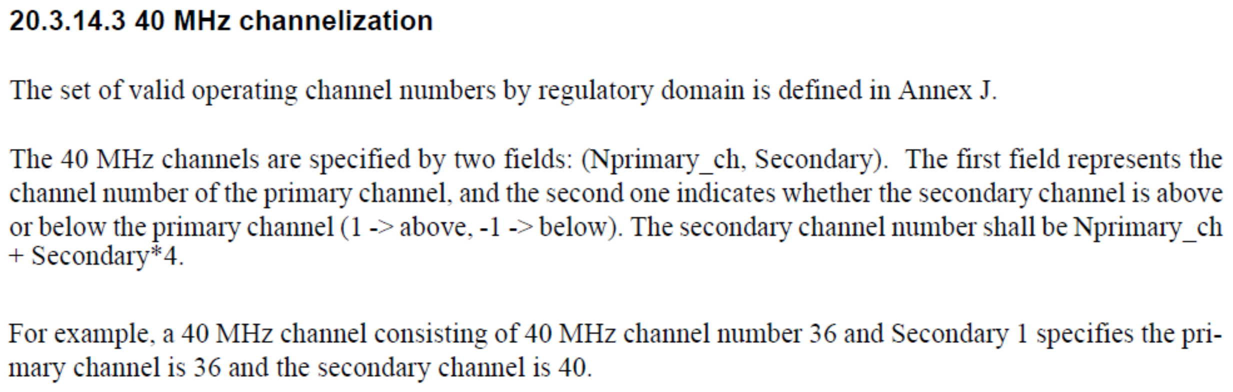
Claim 2 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r^{i_{TX}}_{LEG-DUP}(t-nT_{SYM}) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}}\sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26}(jD_{k,n}+p_nP_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T^{i_{TX}}_{CS}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 2 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz})$ (20-87) where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz})$ (20-88) where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 2 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	**20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

Claim 2 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.20.3

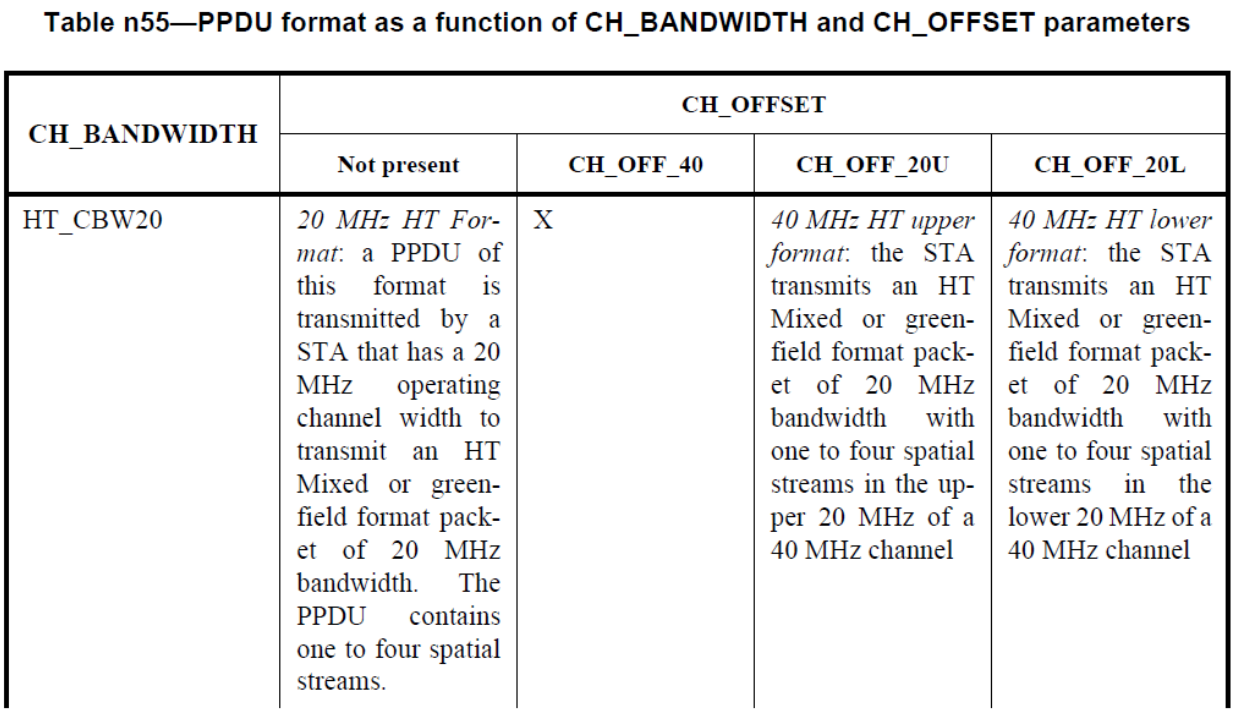
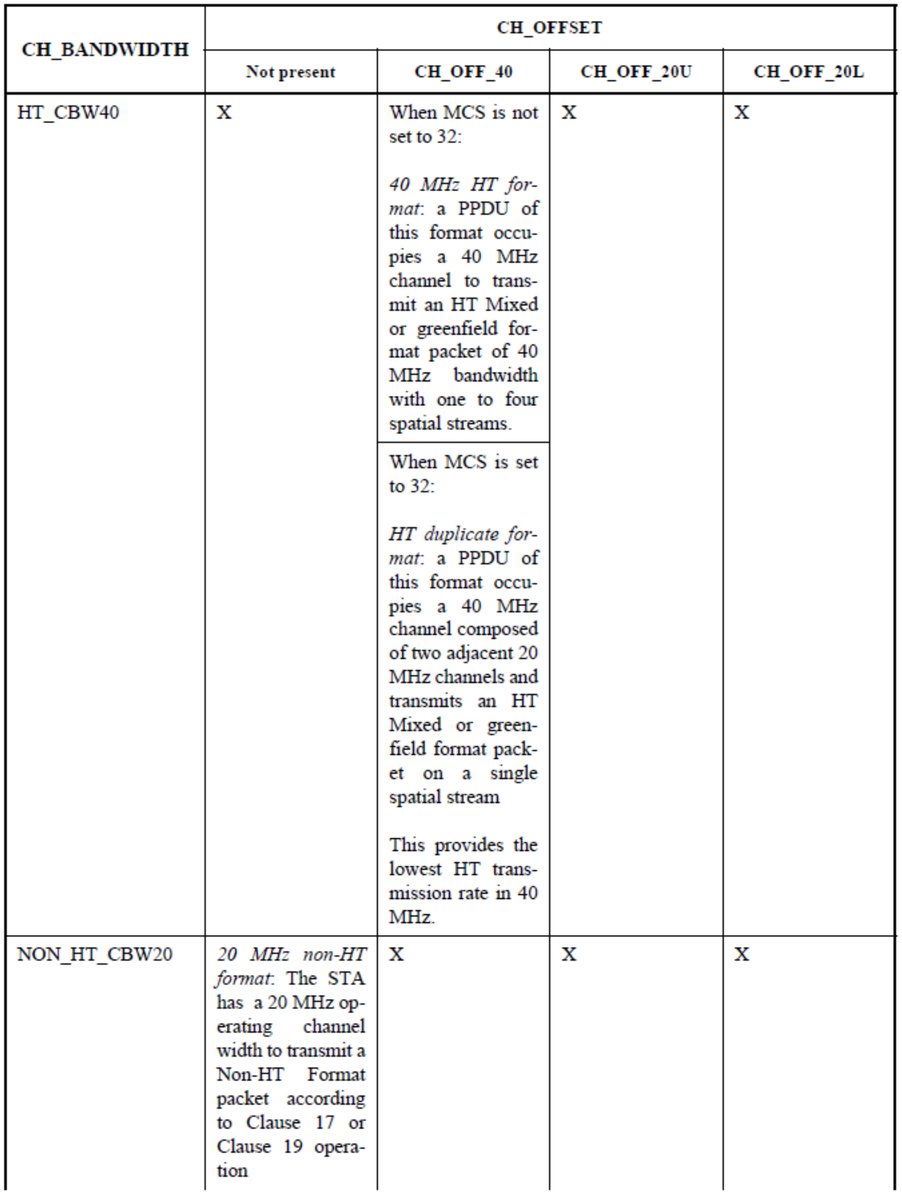
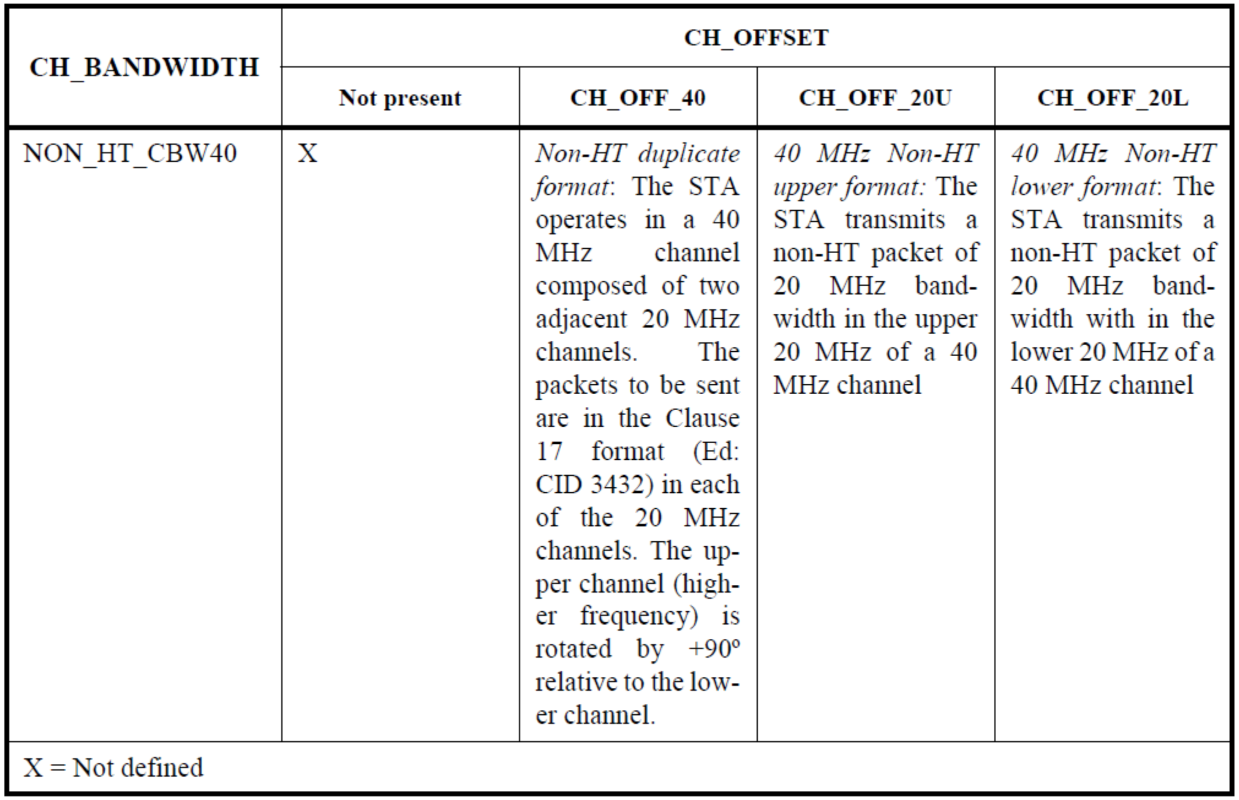


Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel



CH_BANDWIDTH	**CH_OFFSET**			
	Not present	**CH_OFF_40**	**CH_OFF_20U**	**CH_OFF_20L**
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

<table>
<tr><th>Claim 2 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>NON_HT_CBW40</td><td>X</td><td><i>Non-HT duplicate format</i>: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.</td><td><i>40 MHz Non-HT upper format:</i> The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel</td><td><i>40 MHz Non-HT lower format</i>: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel</td></tr>
<tr><td colspan="5">X = Not defined</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n55
</td></tr>
</table>

Claim 2 of the ’802 Patent	Prior Art Reference – 802.11n D2.0

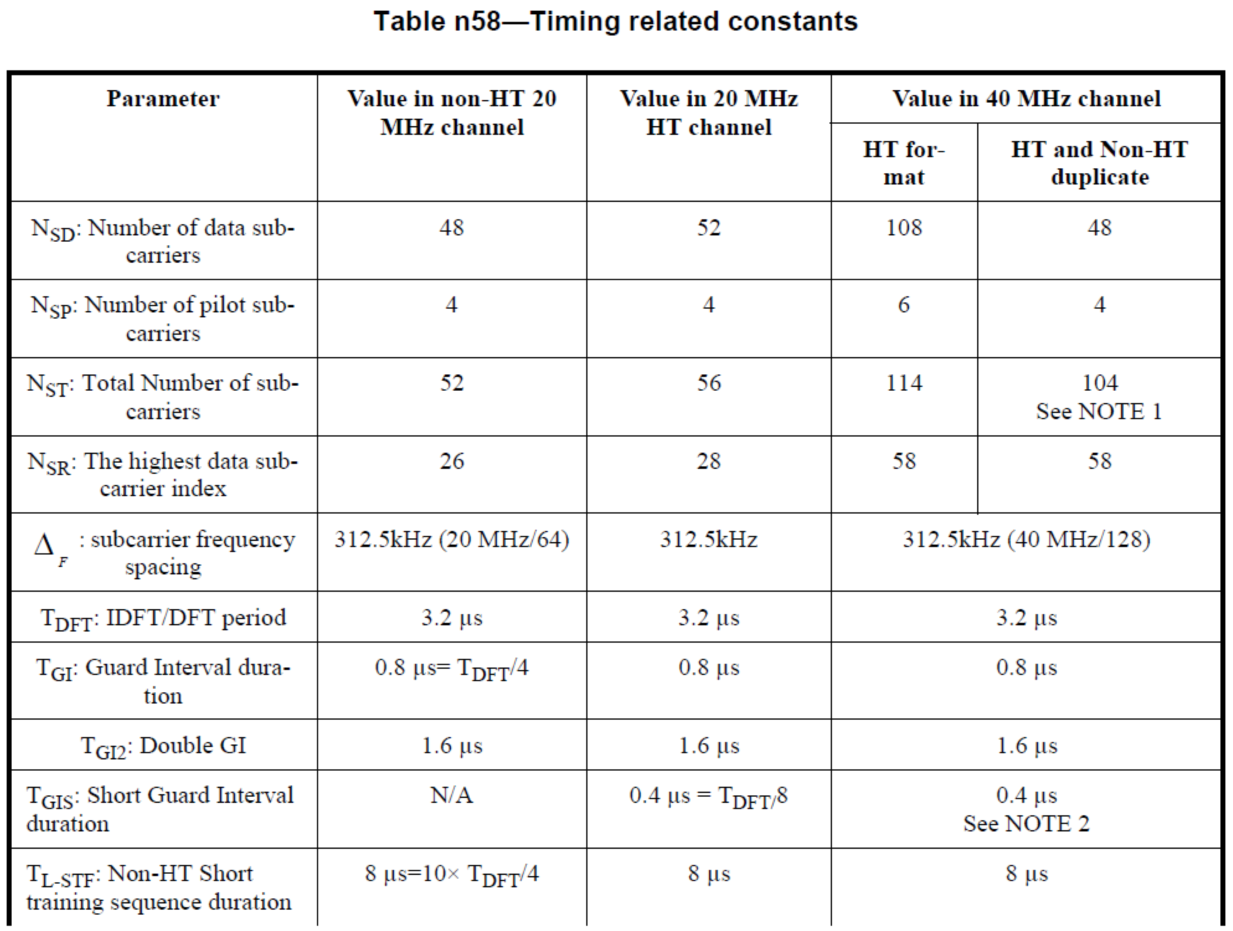
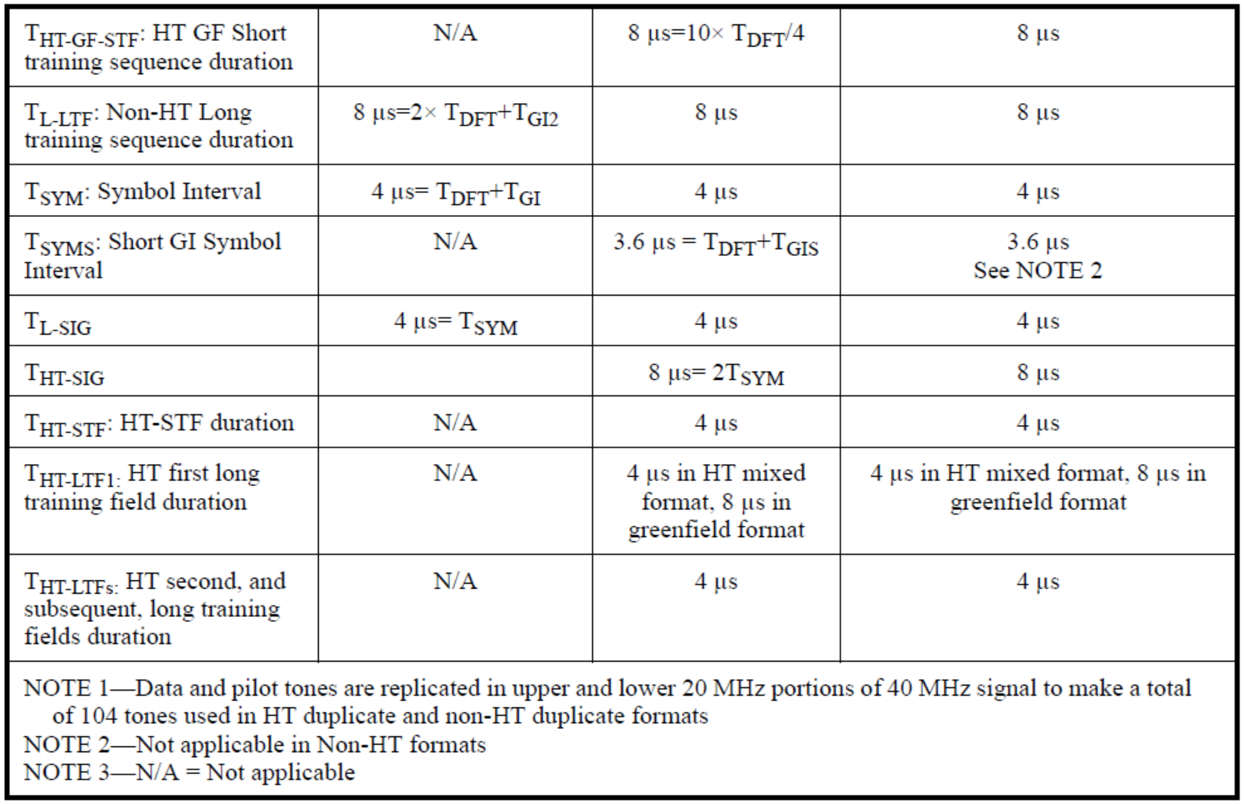


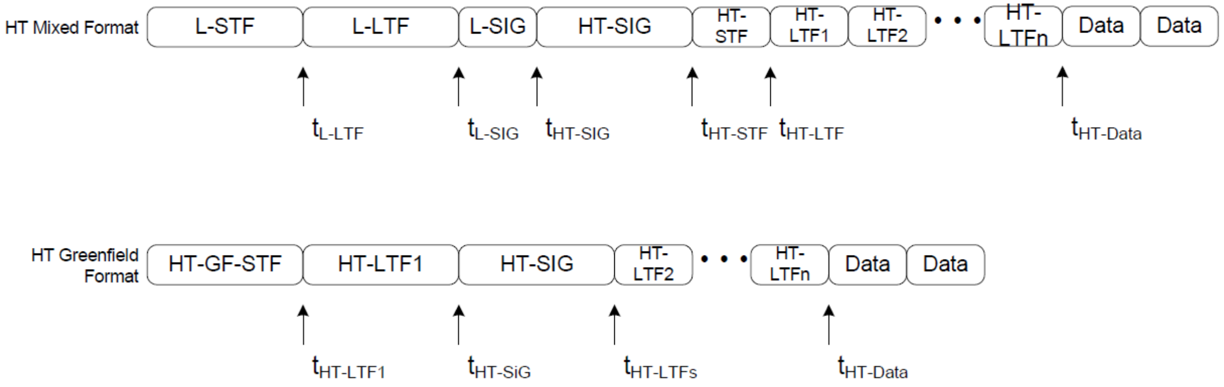
Table n58—Timing related constants

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F: subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

Claim 2 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 See, e.g., 802.11n D2.0 Table n58

$T_{HT\text{-}GF\text{-}STF}$: HT GF Short training sequence duration	N/A	8 μs=10× T_{DFT}/4	8 μs
$T_{L\text{-}LTF}$: Non-HT Long training sequence duration	8 μs=2× T_{DFT}+T_{GI2}	8 μs	8 μs
T_{SYM}: Symbol Interval	4 μs= T_{DFT}+T_{GI}	4 μs	4 μs
T_{SYMS}: Short GI Symbol Interval	N/A	3.6 μs = T_{DFT}+T_{GIS}	3.6 μs See NOTE 2
$T_{L\text{-}SIG}$	4 μs= T_{SYM}	4 μs	4 μs
$T_{HT\text{-}SIG}$		8 μs= 2T_{SYM}	8 μs
$T_{HT\text{-}STF}$: HT-STF duration	N/A	4 μs	4 μs
$T_{HT\text{-}LTF1}$: HT first long training field duration	N/A	4 μs in HT mixed format, 8 μs in greenfield format	4 μs in HT mixed format, 8 μs in greenfield format
$T_{HT\text{-}LTFs}$: HT second, and subsequent, long training fields duration	N/A	4 μs	4 μs

NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable

Claim 2 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.

Claim 3 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
[3.1] The method of claim 1	802.11n D2.0 discloses all the elements of claim 1 for all the reasons provided above.
[3.2] wherein the first and second information are transmitted using the same	802.11n D2.0 discloses “wherein the first and second information are transmitted using the same power amplifier in said wireless transmitter.” See, e.g.:

Claim 3 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
power amplifier in said wireless transmitter.	m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT

Claim 3 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $$r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t\right)\right\} \qquad (20\text{-}1)$$ where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

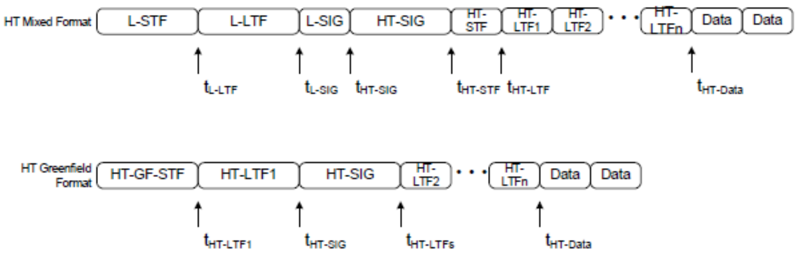


Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right)T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \qquad (20\text{-}2)$$

where

$$t_{L-LTF} = T_{L-STF}$$

$$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$$

$$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$$

$$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1}) \\ & + r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2) T_{HT-LTFs}) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \tag{20-3}$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\text{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

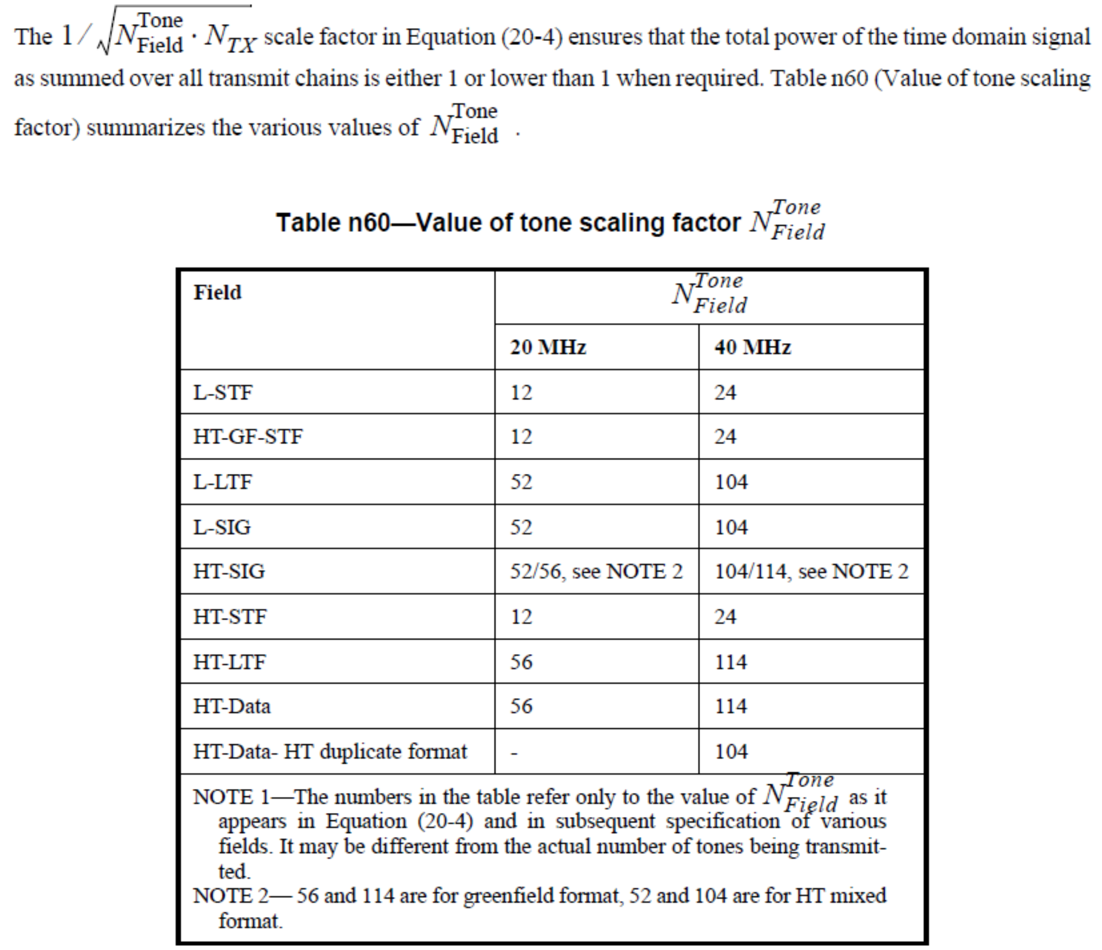
$$r_{\text{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j 2\pi k \Delta_F t) \tag{20-4}$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \tag{20-5}$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \tag{20-6}$$

<table>
<tr><th>Claim 3 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>


The $1/\sqrt{N_{\mathrm{Field}}^{\mathrm{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\mathrm{Field}}^{\mathrm{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

<table>
<tr><th>Field</th><th colspan="2">N_{Field}^{Tone}</th></tr>
<tr><th></th><th>20 MHz</th><th>40 MHz</th></tr>
<tr><td>L-STF</td><td>12</td><td>24</td></tr>
<tr><td>HT-GF-STF</td><td>12</td><td>24</td></tr>
<tr><td>L-LTF</td><td>52</td><td>104</td></tr>
<tr><td>L-SIG</td><td>52</td><td>104</td></tr>
<tr><td>HT-SIG</td><td>52/56, see NOTE 2</td><td>104/114, see NOTE 2</td></tr>
<tr><td>HT-STF</td><td>12</td><td>24</td></tr>
<tr><td>HT-LTF</td><td>56</td><td>114</td></tr>
<tr><td>HT-Data</td><td>56</td><td>114</td></tr>
<tr><td>HT-Data- HT duplicate format</td><td>-</td><td>104</td></tr>
<tr><td colspan="3">NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.
NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.</td></tr>
</table>

See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art.
</td></tr>
</table>

Claim 3 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.

Claim 4 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
[4.1] The method of claim 3	802.11n D2.0 discloses all the elements of claim 3 for all the reasons provided above.
[4.2] wherein the bandwidth of said power amplifier is greater than the difference between the first lowest frequency and the second highest frequency.	802.11n D2.0 discloses “wherein the bandwidth of said power amplifier is greater than the difference between the first lowest frequency and the second highest frequency.” See, e.g.: m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF

Claim 4 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t \right) \right\} \quad (20\text{-}1)$ where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

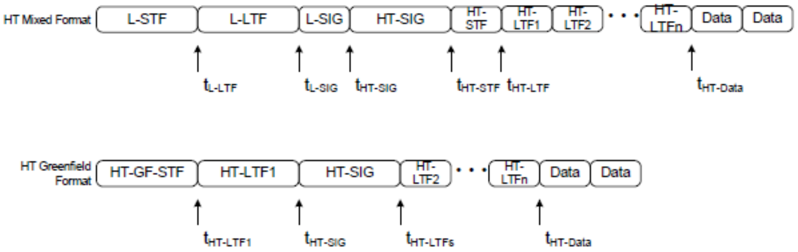


Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) \; = \; & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right)T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \qquad (20\text{-}2)$$

where

$$t_{L-LTF} = T_{L-STF}$$

$$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$$

$$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$$

$$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1}) \\ & + r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2)T_{HT-LTFs}) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \qquad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\text{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\text{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j2\pi k \Delta_F t) \qquad (20\text{-}4)$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \qquad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \qquad (20\text{-}6)$$

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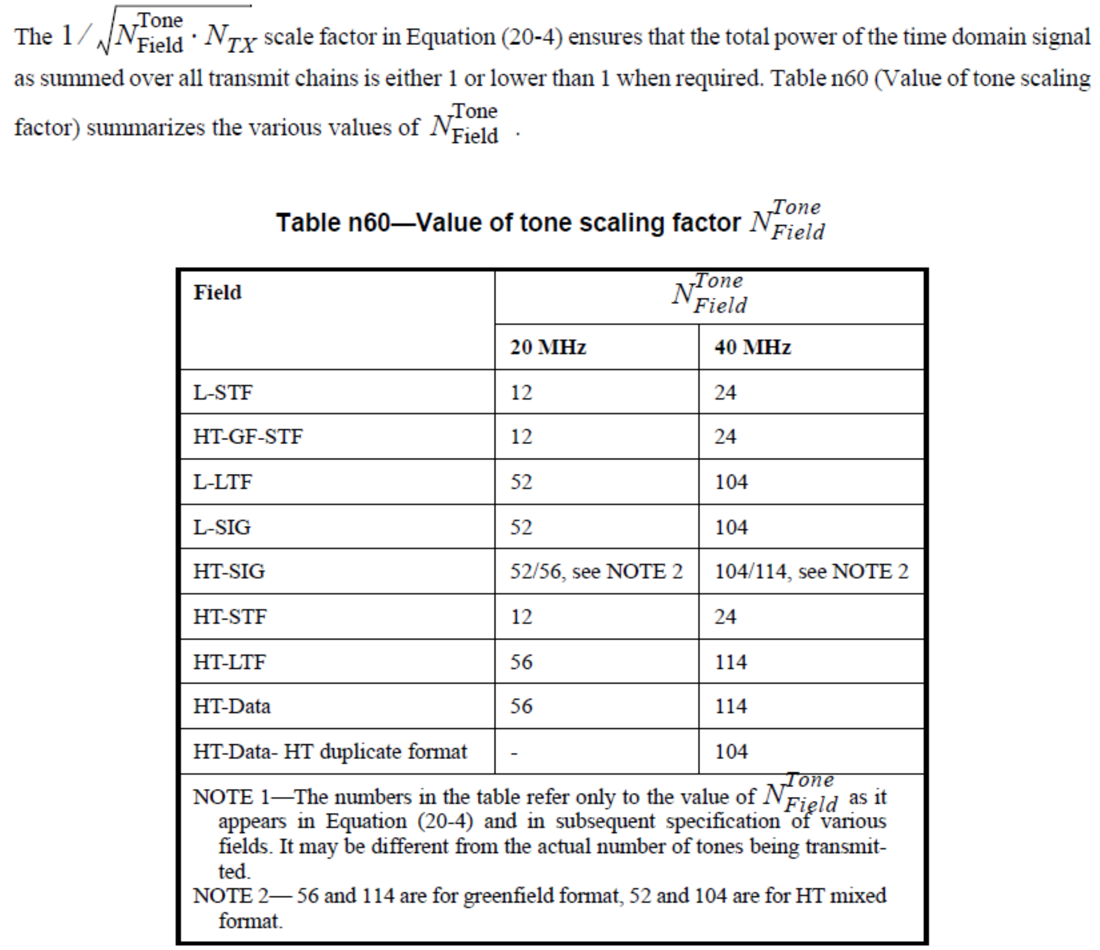


The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	**40 MHz**
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

20.3.20.2 Spectral flatness

In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17

Claim 4 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.

Claim 6 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
[6.1] The method of claim 1	802.11n D2.0 discloses all the elements of claim 1 for all the reasons provided above.
[6.2] wherein the first information corresponds to a first wireless protocol and the second information corresponds to a second wireless protocol.	802.11n D2.0 discloses “wherein the first information corresponds to a first wireless protocol and the second information corresponds to a second wireless protocol.” See, e.g.: **high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19

Claim 6 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	non-HT duplicate: A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

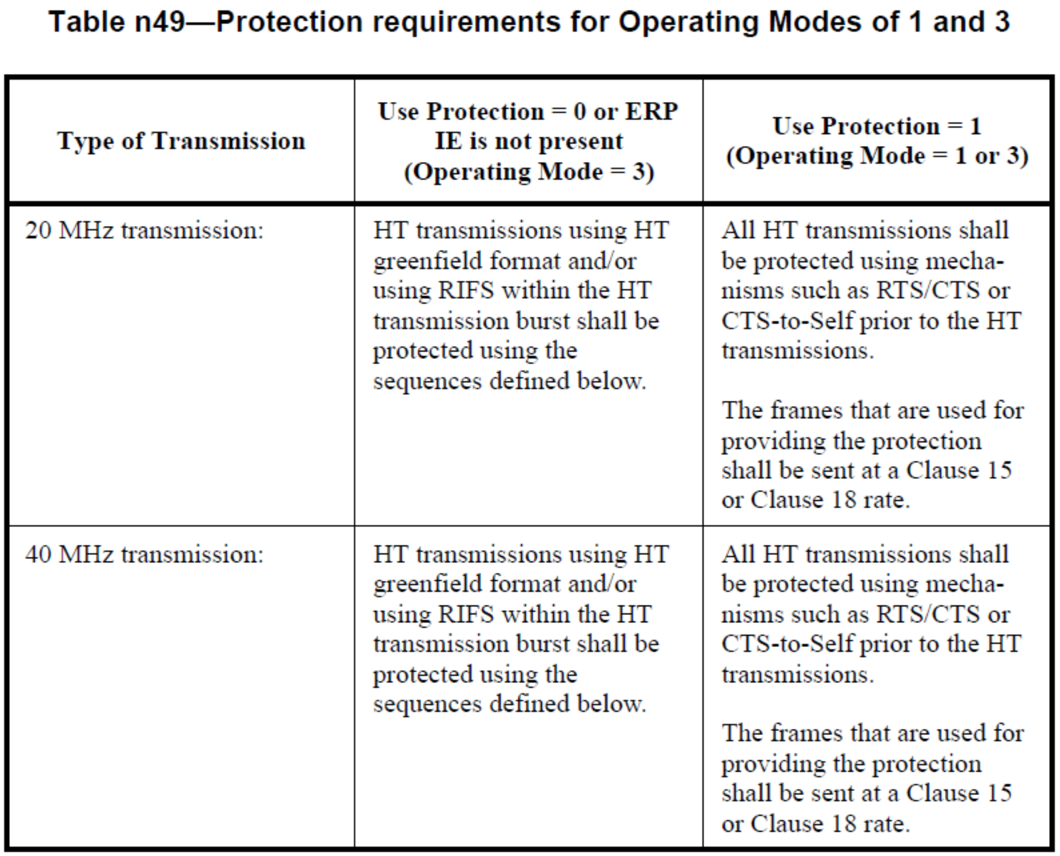
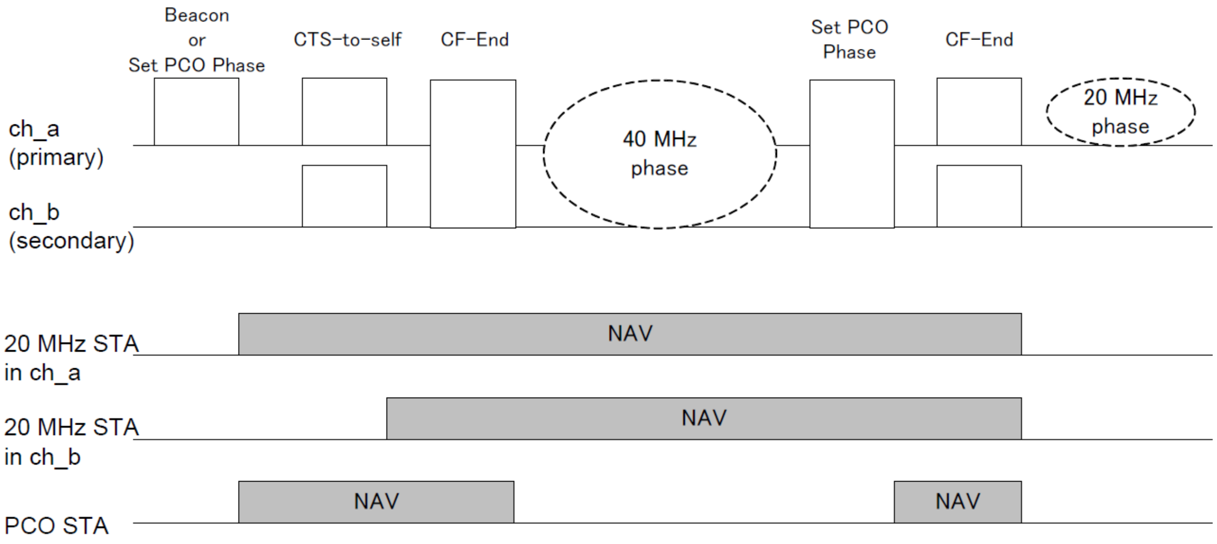
<table>
<tr><th>Claim 6 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>


Table n49—Protection requirements for Operating Modes of 1 and 3

<table>
<tr><th>Type of Transmission</th><th>Use Protection = 0 or ERP IE is not present (Operating Mode = 3)</th><th>Use Protection = 1 (Operating Mode = 1 or 3)</th></tr>
<tr><td>20 MHz transmission:</td><td>HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.</td><td>All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions.
The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.</td></tr>
<tr><td>40 MHz transmission:</td><td>HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.</td><td>All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions.
The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.</td></tr>
</table>

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.
NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).
</td></tr>
</table>

Claim 6 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

<table>
<tr><th>Claim 6 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>


A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU.
During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel.
During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS.
A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS.
The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.
</td></tr>
</table>

Claim 6 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 6 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

Claim 6 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

Claim 6 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

Claim 6 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t \right) \right\}$ (20-1) where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

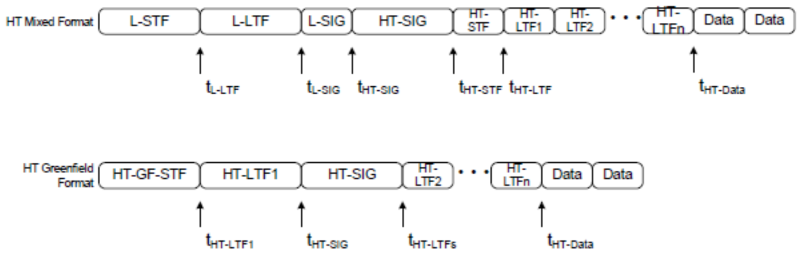


Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) \;=\; & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right)T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \qquad (20\text{-}2)$$

where

$$t_{L-LTF} = T_{L-STF}$$

$$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$$

$$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$$

$$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1}) \\ & + r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2)T_{HT-LTFs}) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \quad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\text{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\text{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j 2\pi k \Delta_F t) \quad (20\text{-}4)$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \quad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \quad (20\text{-}6)$$

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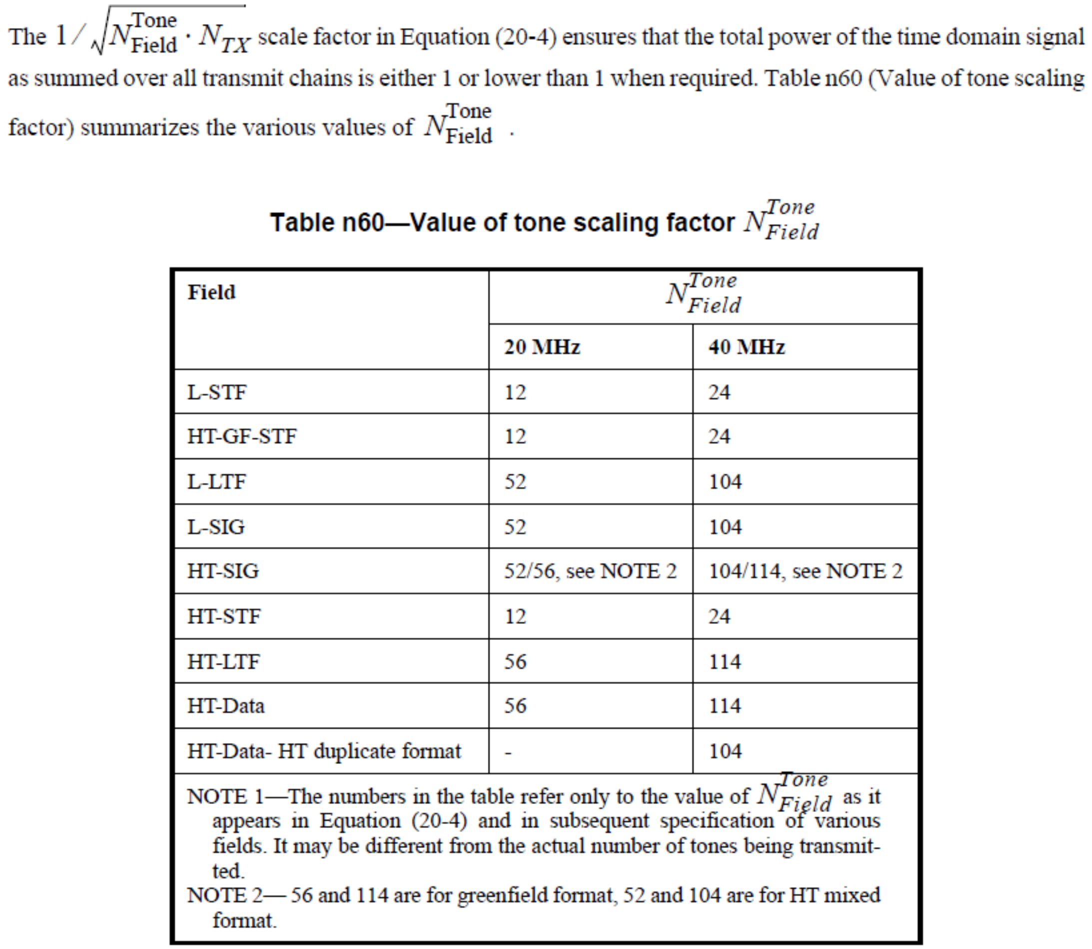


The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

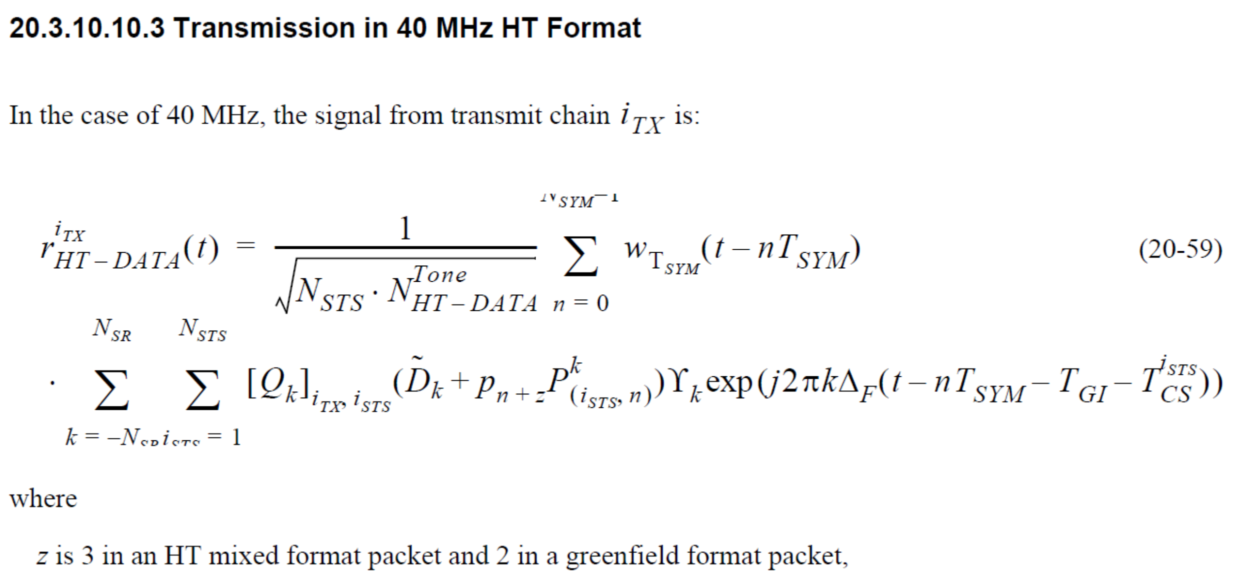
Field	N_{Field}^{Tone}	
	20 MHz	40 MHz
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

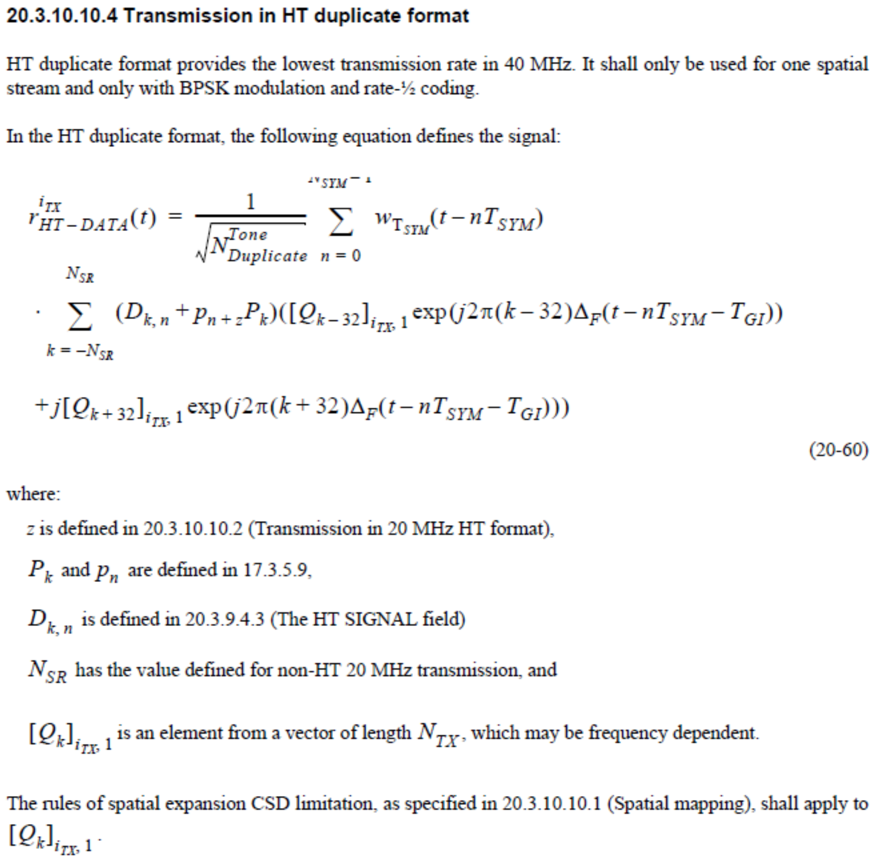
NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.
NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

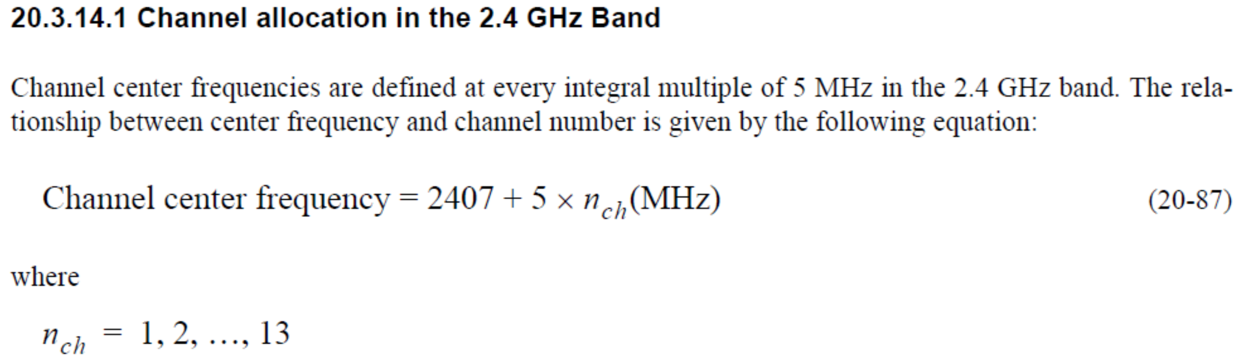
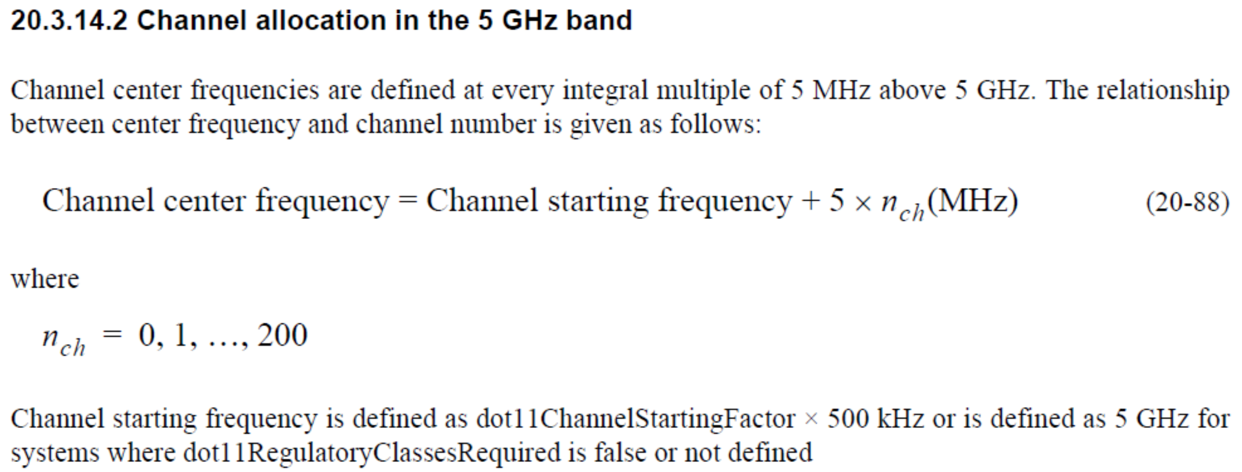
20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel
When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

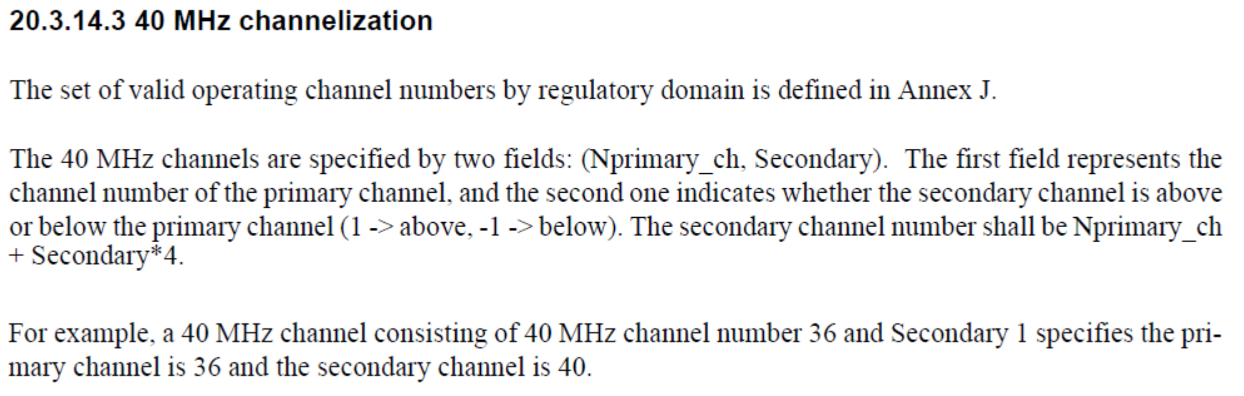
Claim 6 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \leq i_{TX} \leq N_{TX}$ is: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS} \cdot N^{Tone}_{HT-DATA}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P^k_{(i_{STS},n)}) \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T^{i_{STS}}_{CS}))$ (20-58) where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

Claim 6 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P_{(i_{STS}, n)}^{k}) \Upsilon_k \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (20-59) where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

Claim 6 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n}+p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI})) + j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

Claim 6 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	20.3.10.11 Non-HT duplicate transmission Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r_{LEG-DUP}^{i_{TX}}(t-nT_{SYM}) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n}+p_nP_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{TX}})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{TX}})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T_{CS}^{i_{TX}}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 6 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz})$ (20-87) where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz})$ (20-88) where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 6 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

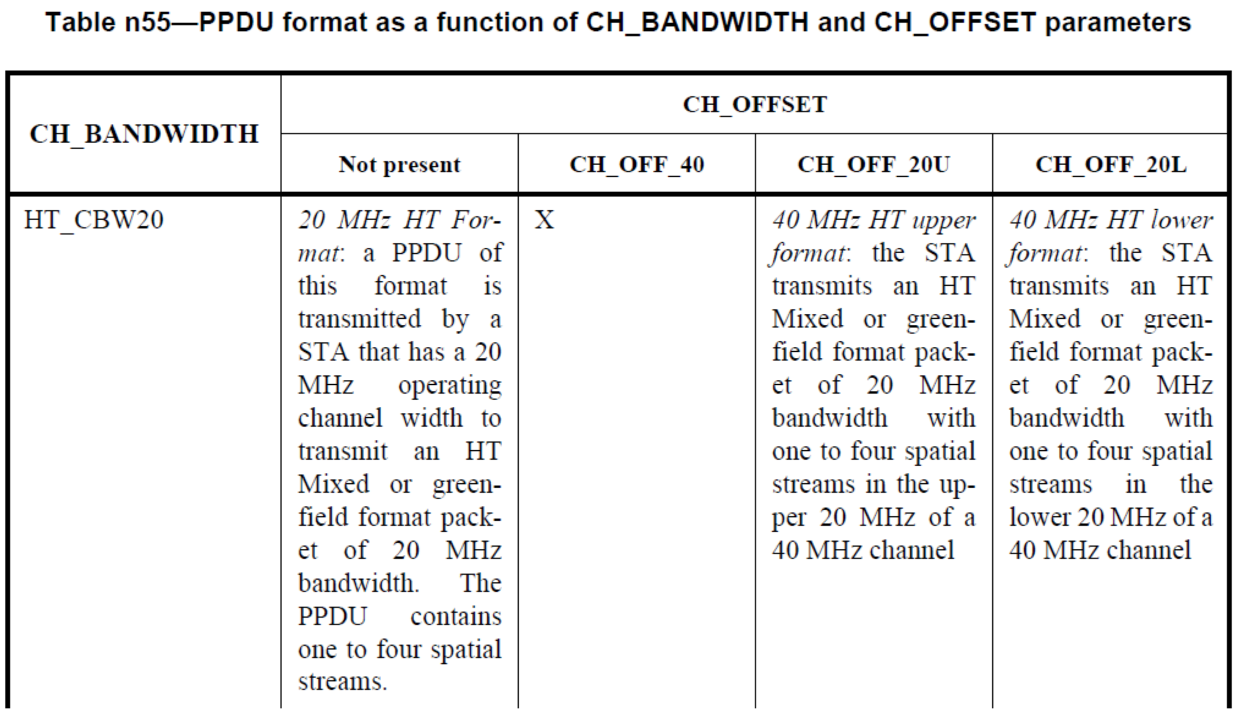
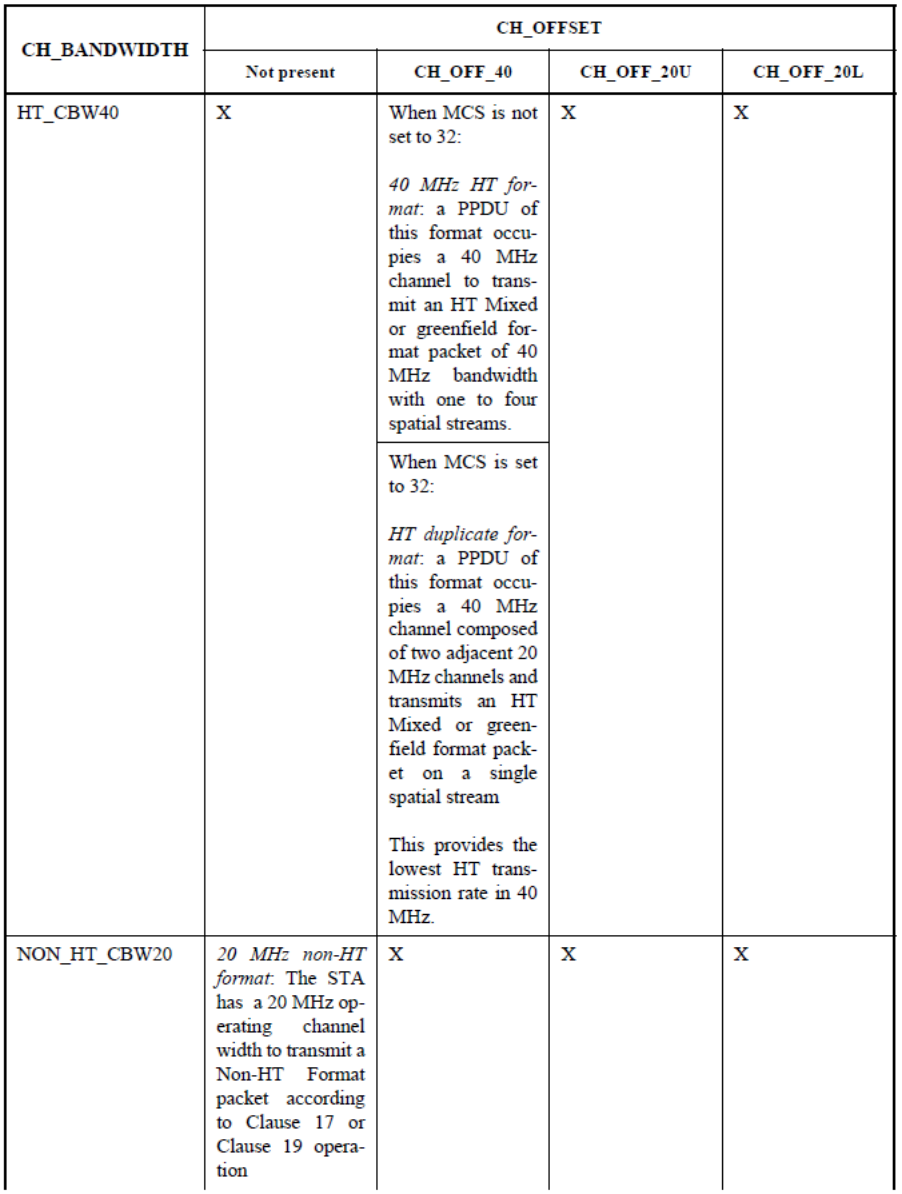
Claim 6 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.20.3 

Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

CH_BANDWIDTH	**CH_OFFSET**			
	Not present	**CH_OFF_40**	**CH_OFF_20U**	**CH_OFF_20L**
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel



CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

<table>
<tr><th>Claim 6 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
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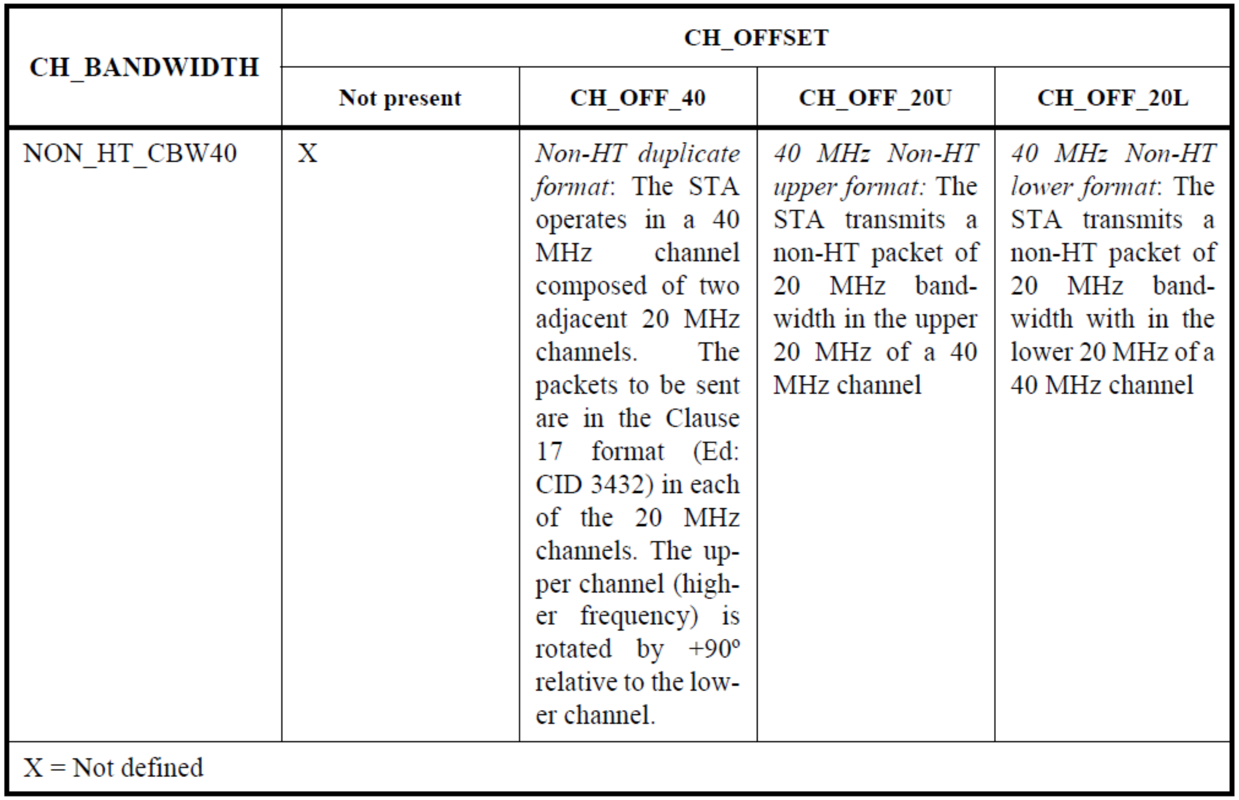
<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>NON_HT_CBW40</td><td>X</td><td><i>Non-HT duplicate format</i>: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.</td><td><i>40 MHz Non-HT upper format:</i> The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel</td><td><i>40 MHz Non-HT lower format</i>: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel</td></tr>
<tr><td colspan="5">X = Not defined</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n55
</td></tr>
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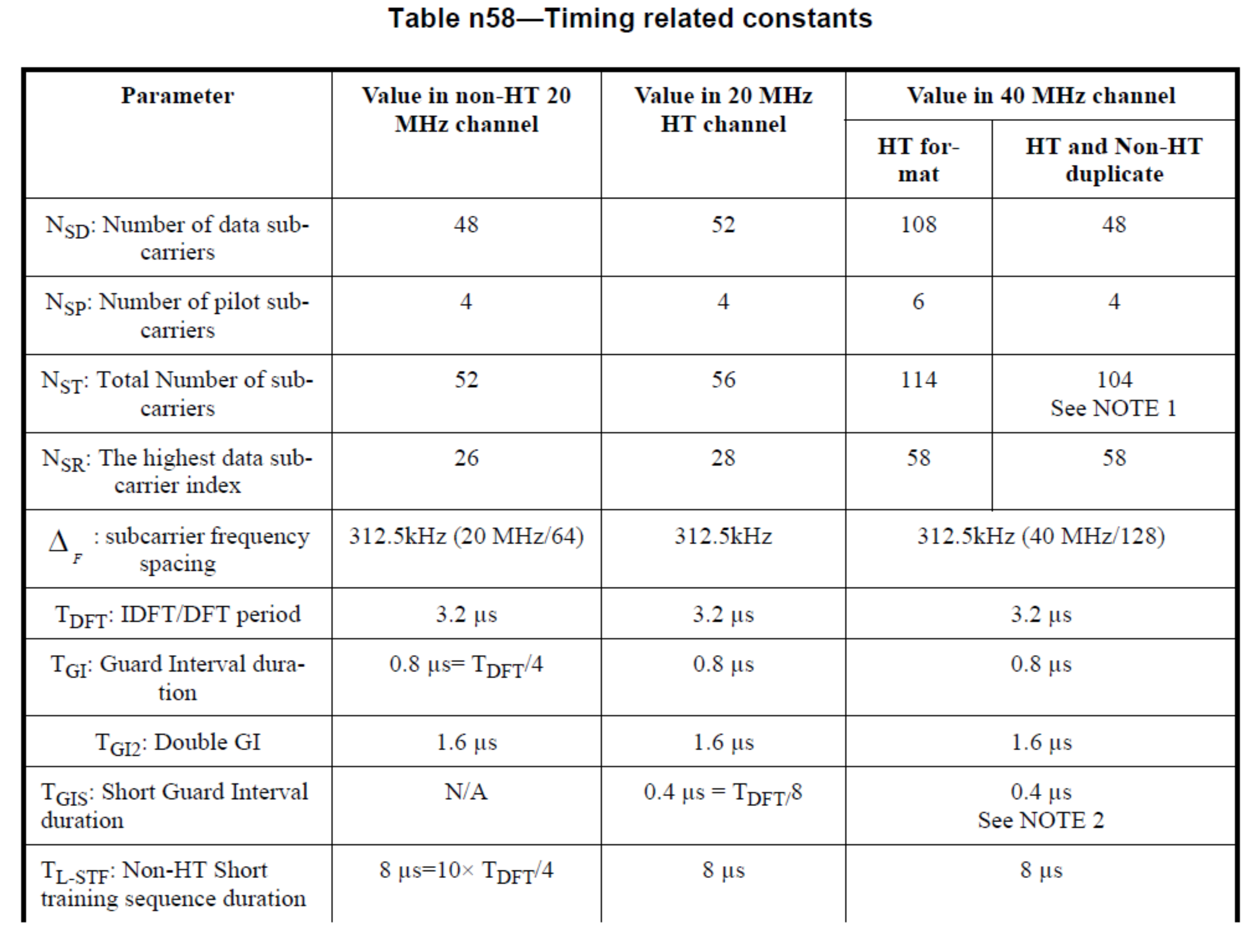
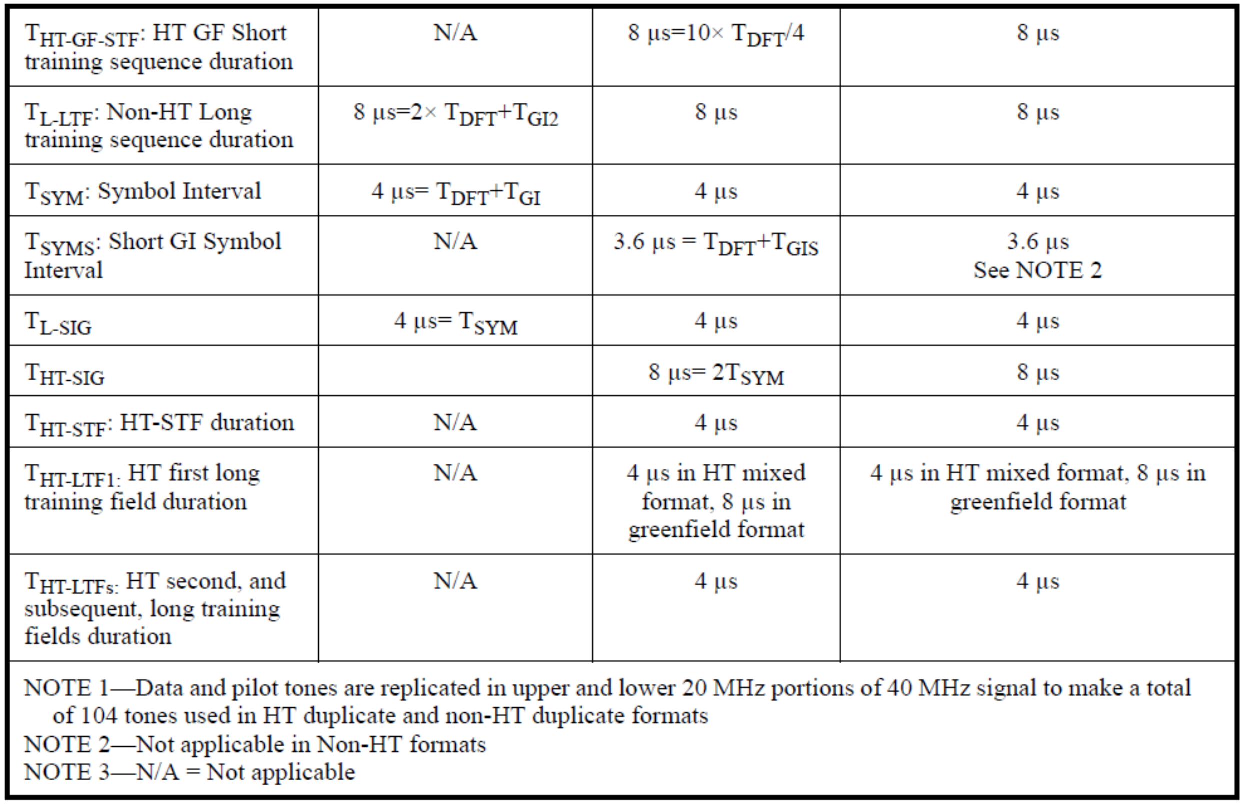
Claim 6 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	

Table n58—Timing related constants

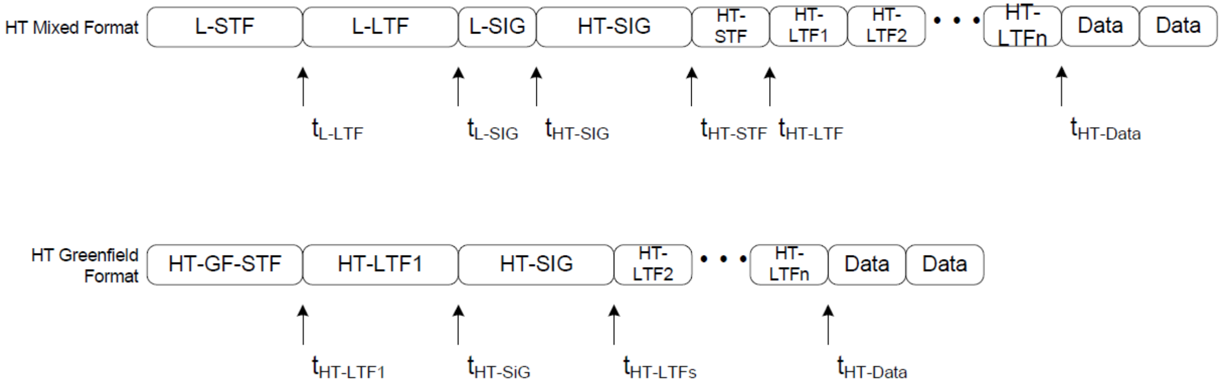
Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F: subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= T_{DFT}/4	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = T_{DFT}/8	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× T_{DFT}/4	8 µs	8 µs	

Claim 6 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	

$T_{HT\text{-}GF\text{-}STF}$: HT GF Short training sequence duration	N/A	8 μs=10× $T_{DFT}/4$	8 μs
$T_{L\text{-}LTF}$: Non-HT Long training sequence duration	8 μs=2× $T_{DFT}+T_{GI2}$	8 μs	8 μs
T_{SYM}: Symbol Interval	4 μs= $T_{DFT}+T_{GI}$	4 μs	4 μs
T_{SYMS}: Short GI Symbol Interval	N/A	3.6 μs = $T_{DFT}+T_{GIS}$	3.6 μs See NOTE 2
$T_{L\text{-}SIG}$	4 μs= T_{SYM}	4 μs	4 μs
$T_{HT\text{-}SIG}$		8 μs= $2T_{SYM}$	8 μs
$T_{HT\text{-}STF}$: HT-STF duration	N/A	4 μs	4 μs
$T_{HT\text{-}LTF1}$: HT first long training field duration	N/A	4 μs in HT mixed format, 8 μs in greenfield format	4 μs in HT mixed format, 8 μs in greenfield format
$T_{HT\text{-}LTFs}$: HT second, and subsequent, long training fields duration	N/A	4 μs	4 μs

NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable

See, e.g., 802.11n D2.0 Table n58

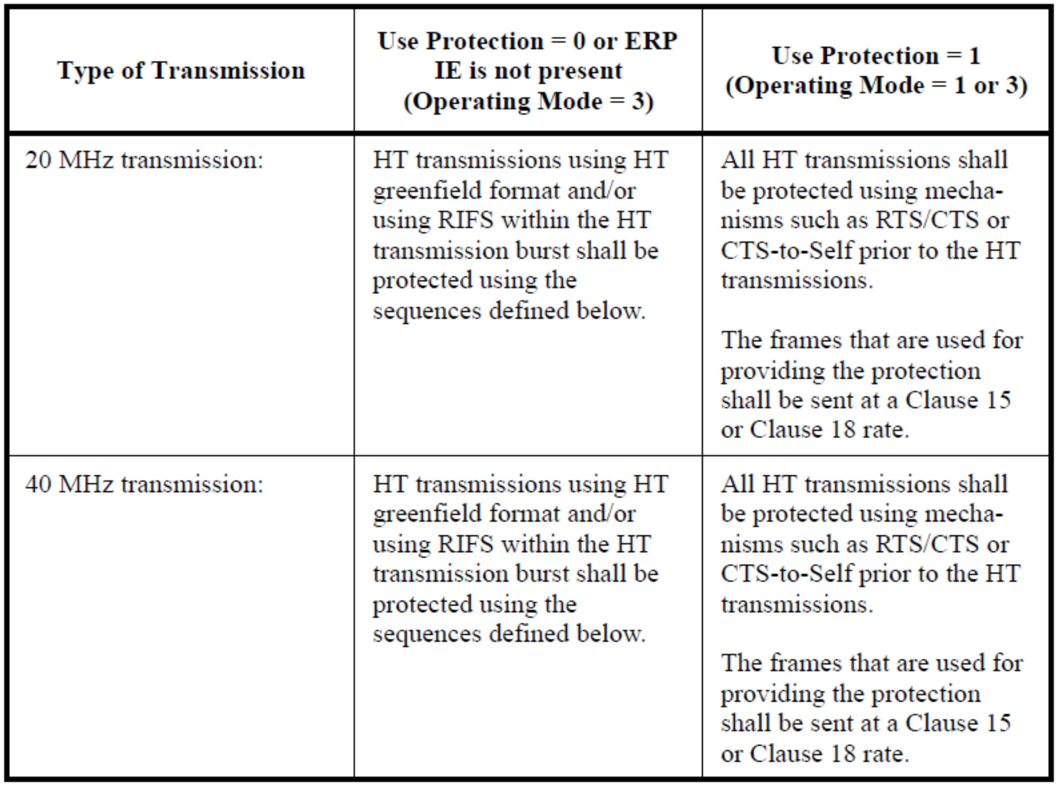
Claim 6 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.

Claim 7 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
[7.1] The method of claim 1	802.11n D2.0 discloses all the elements of claim 1 for all the reasons provided above.
[7.2] wherein the first information and the second information are the same data	802.11n D2.0 discloses “wherein the first information and the second information are the same data transmitted across two different frequencies.” See, e.g.:

Claim 7 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
transmitted across two different frequencies.	**high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19 **non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

<table>
<tr><th>Claim 7 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

Table n49—Protection requirements for Operating Modes of 1 and 3

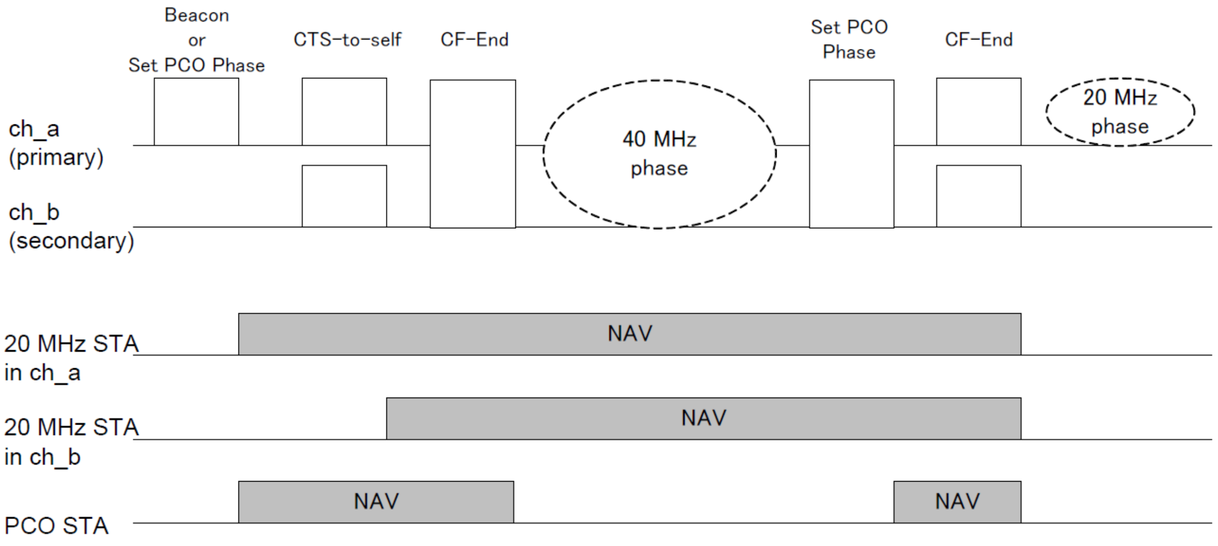


<table>
<tr><th>Type of Transmission</th><th>Use Protection = 0 or ERP IE is not present (Operating Mode = 3)</th><th>Use Protection = 1 (Operating Mode = 1 or 3)</th></tr>
<tr><td>20 MHz transmission:</td><td>HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.</td><td>All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions.
The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.</td></tr>
<tr><td>40 MHz transmission:</td><td>HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.</td><td>All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions.
The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.</td></tr>
</table>

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.
NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).

</td></tr>
</table>

Claim 7 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

Claim 7 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

Claim 7 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format*: packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format*: packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format*: HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 7 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

Claim 7 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

Claim 7 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

Claim 7 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\left\{ r(t) \exp\left(j 2\pi f_c t \right) \right\} \quad (20\text{-}1)$ where $\mathrm{Re}\left\{ \cdot \right\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

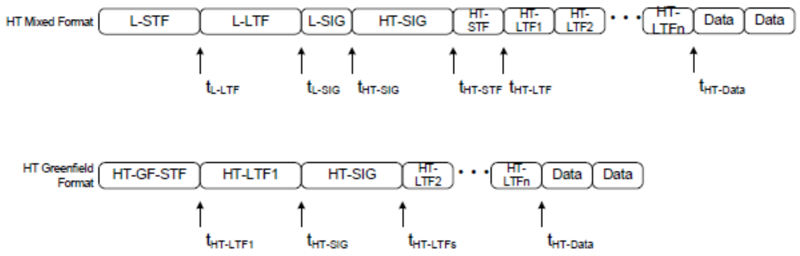


Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right) T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}\left(t - t_{HT-DATA}\right) \end{aligned} \tag{20-2}$$

where

$t_{L-LTF} = T_{L-STF}$

$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$

$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$

$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1}) \\ & + r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2)T_{HT-LTFs}) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \quad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\text{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\text{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j 2\pi k \Delta_F t) \quad (20\text{-}4)$$

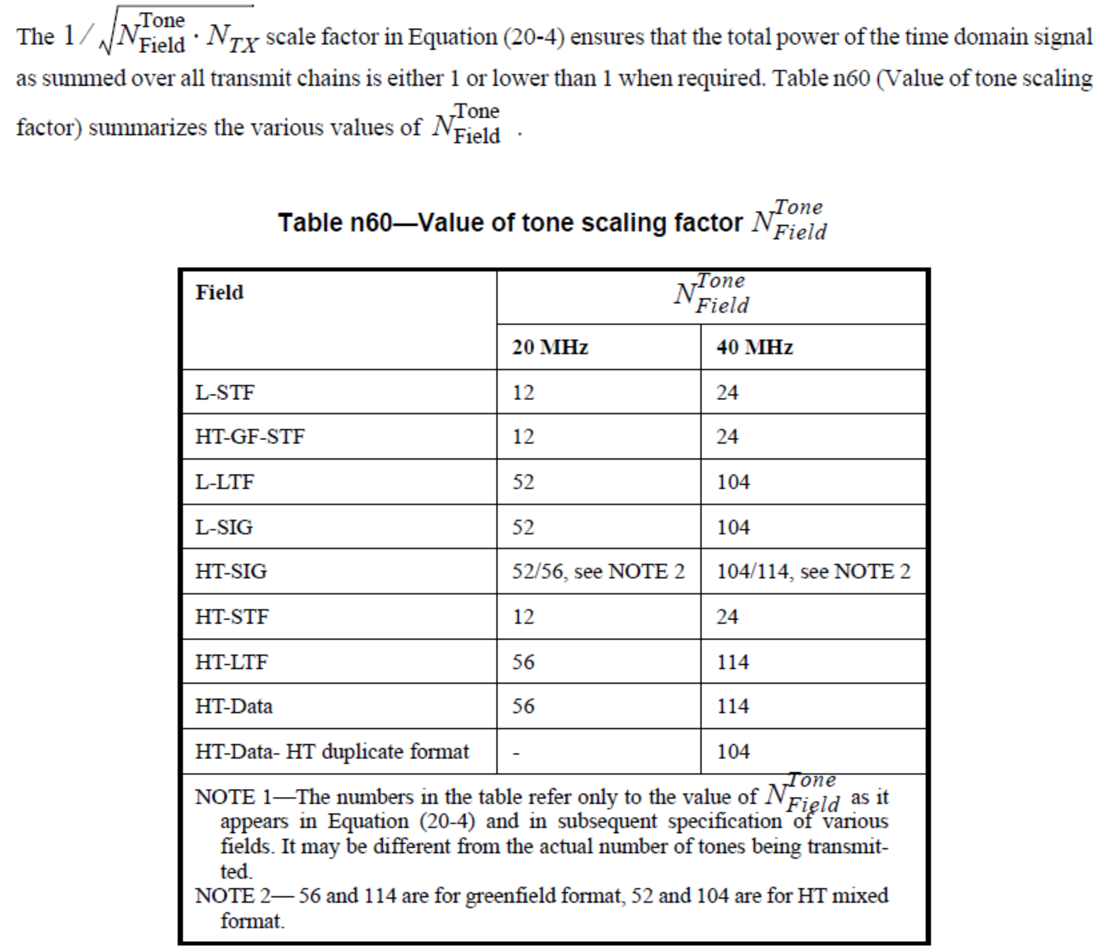
This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \quad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \quad (20\text{-}6)$$

Claim 7 of the ’802 Patent	Prior Art Reference – 802.11n D2.0



The $1 / \sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	40 MHz
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

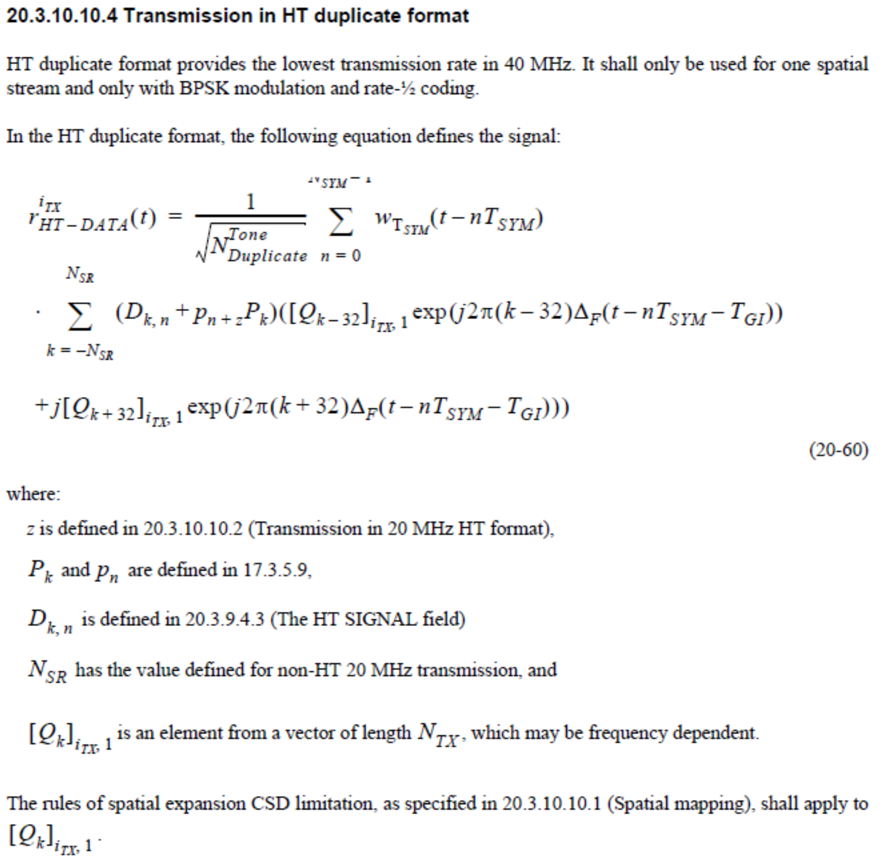
See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

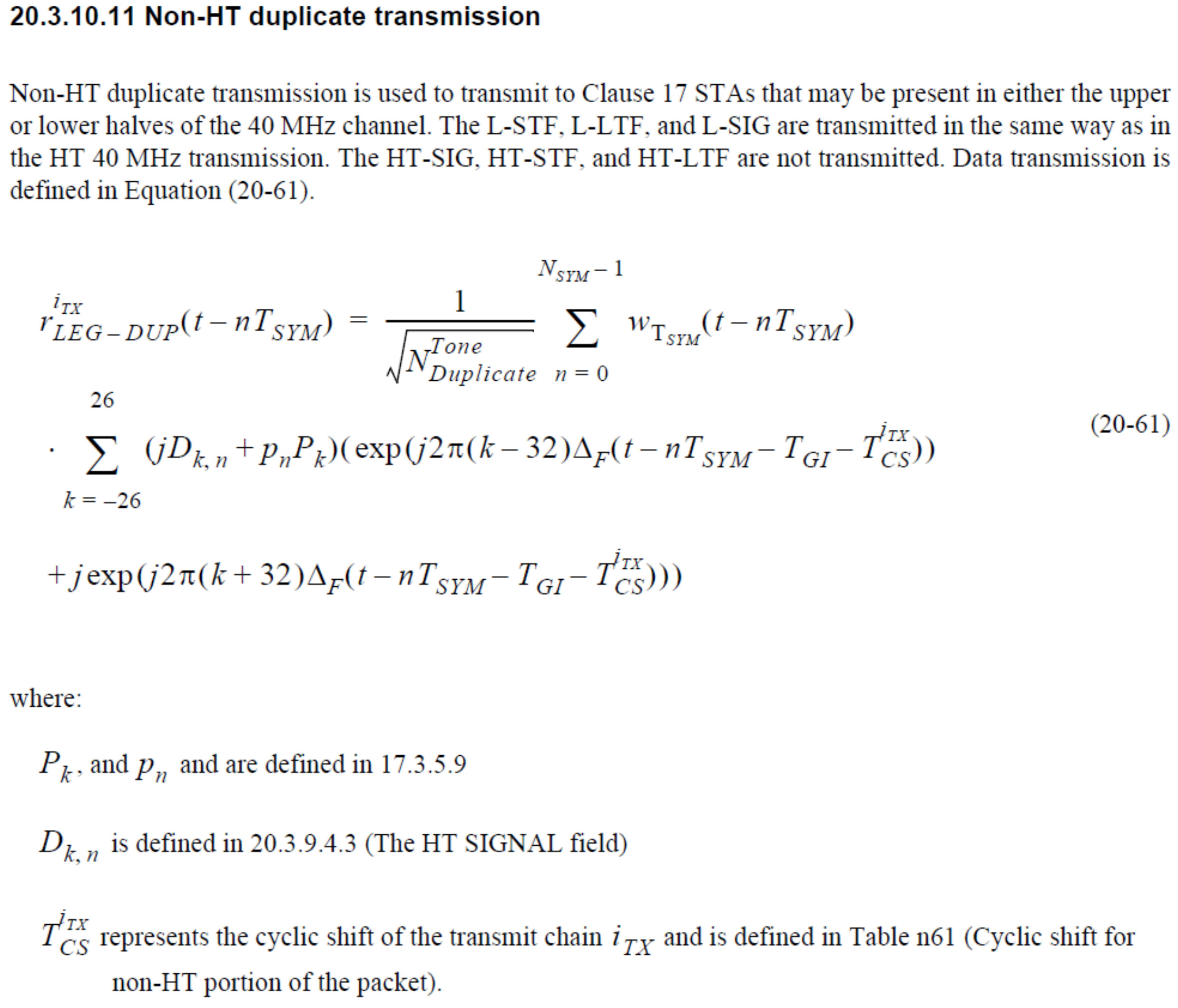
20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

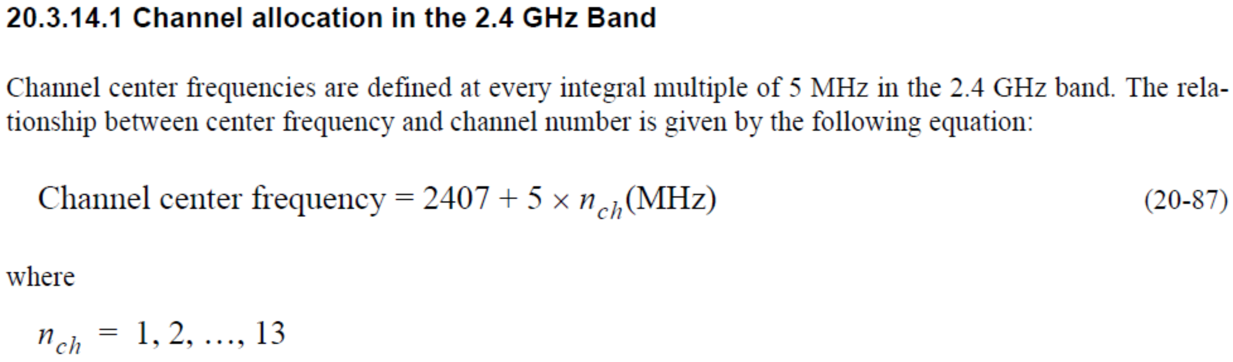
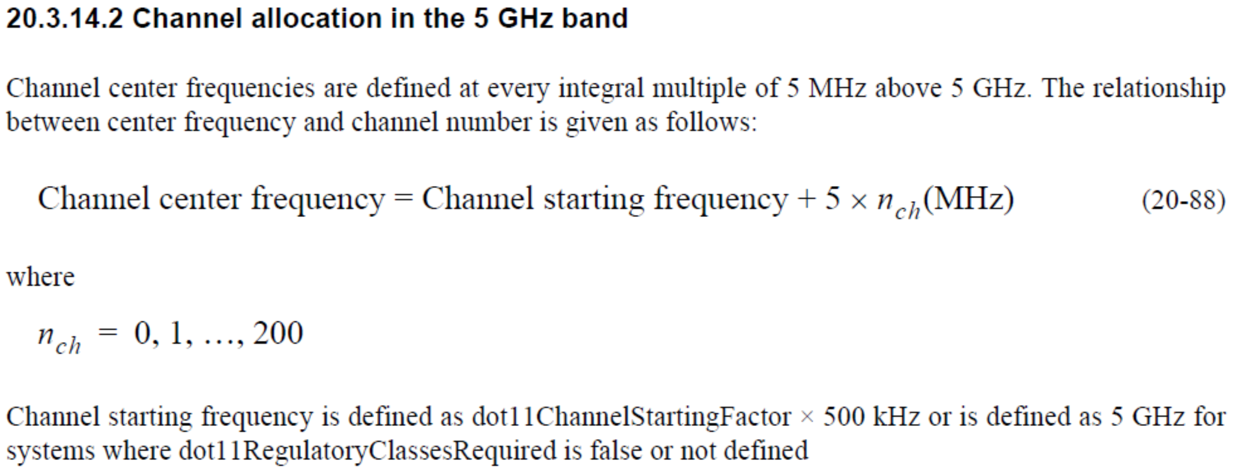
When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

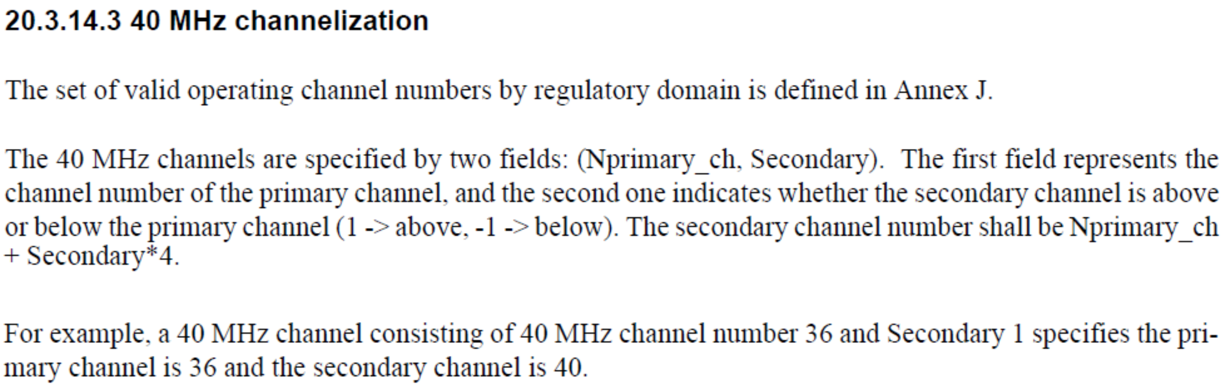
Claim 7 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS} \cdot N^{Tone}_{HT-DATA}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P^k_{(i_{STS},n)}) \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T^{i_{STS}}_{CS}))$ (20-58) where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

Claim 7 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.10.10.2 **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $$r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P_{(i_{STS}, n)}^{k}) \Upsilon_k \exp(j2\pi k\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{STS}})) \quad (20\text{-}59)$$ where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

Claim 7 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n} + p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t - nT_{SYM} - T_{GI})) + j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t - nT_{SYM} - T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

Claim 7 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r^{i_{TX}}_{LEG-DUP}(t - nT_{SYM}) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n} + p_n P_k)(\exp(j2\pi(k-32)\Delta_F(t - nT_{SYM} - T_{GI} - T^{i_{TX}}_{CS})) + j\exp(j2\pi(k+32)\Delta_F(t - nT_{SYM} - T_{GI} - T^{i_{TX}}_{CS})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T^{i_{TX}}_{CS}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 7 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz}) \quad (20\text{-}87)$ where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz}) \quad (20\text{-}88)$ where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 7 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

Claim 7 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.20.3

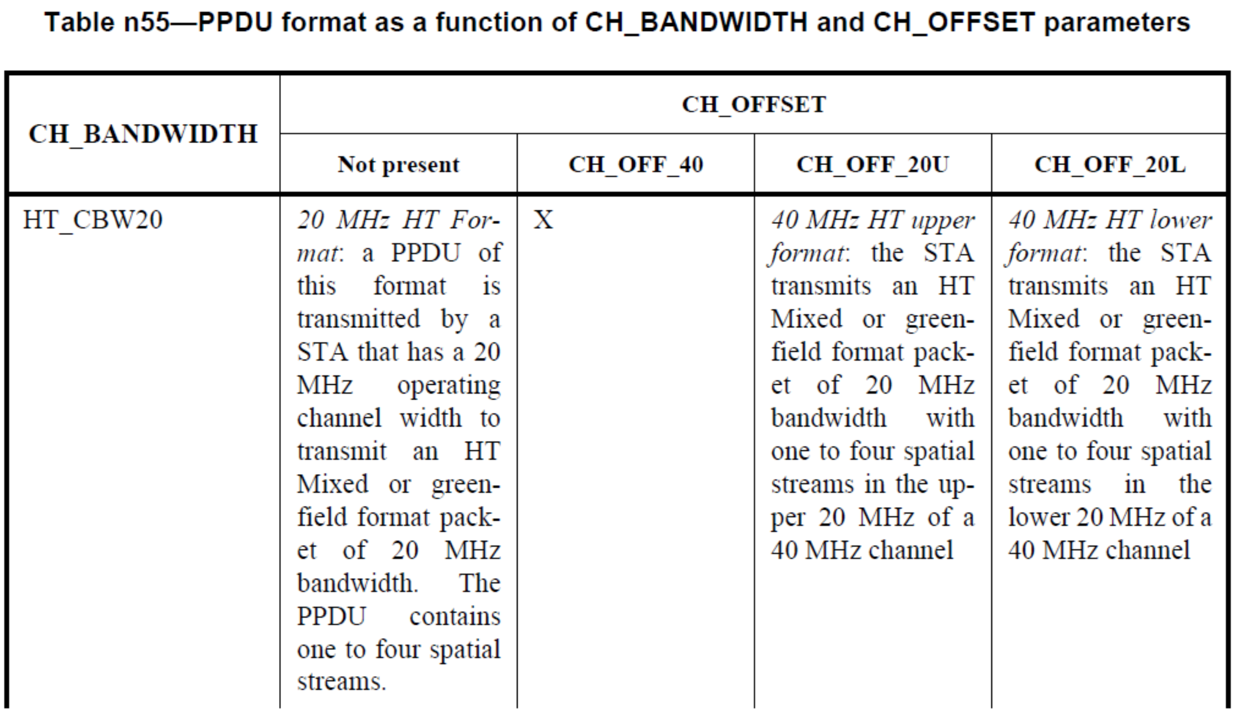
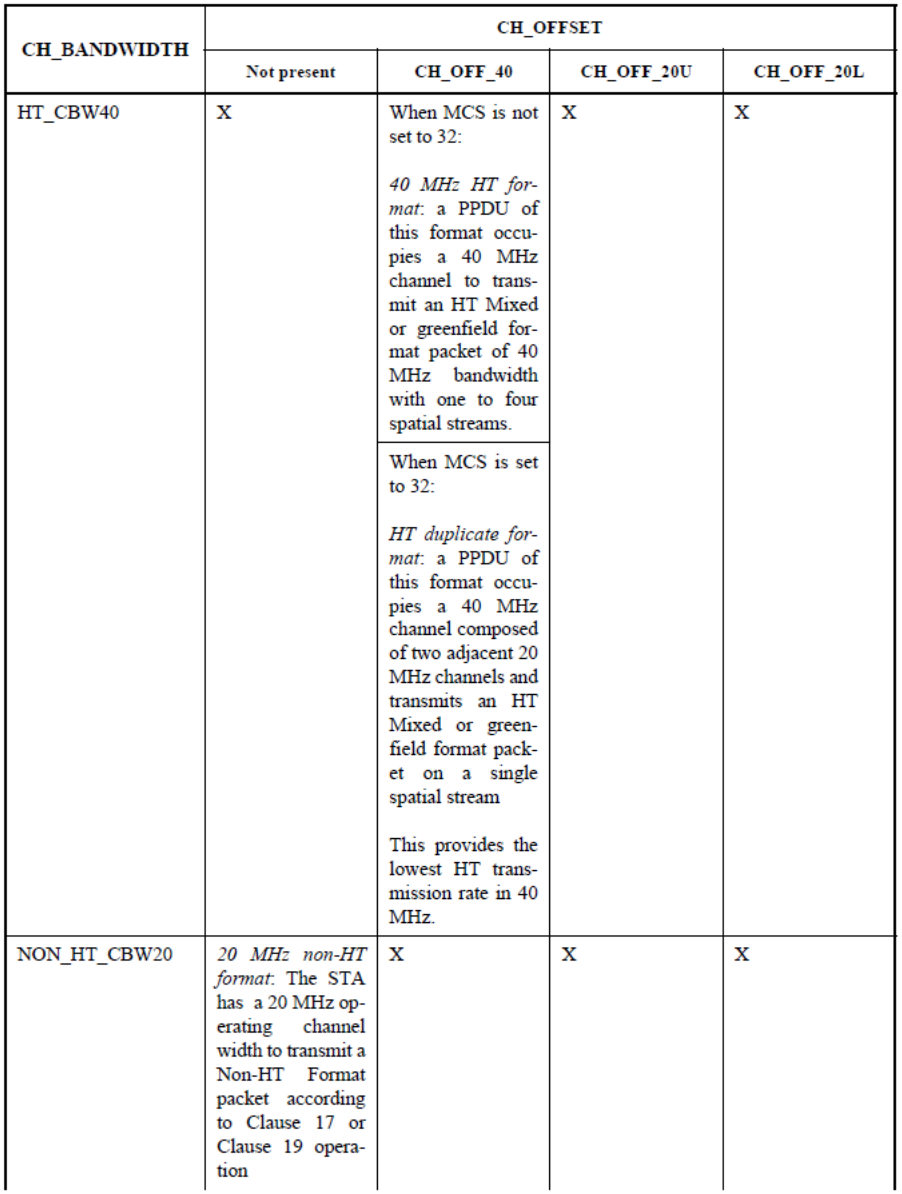
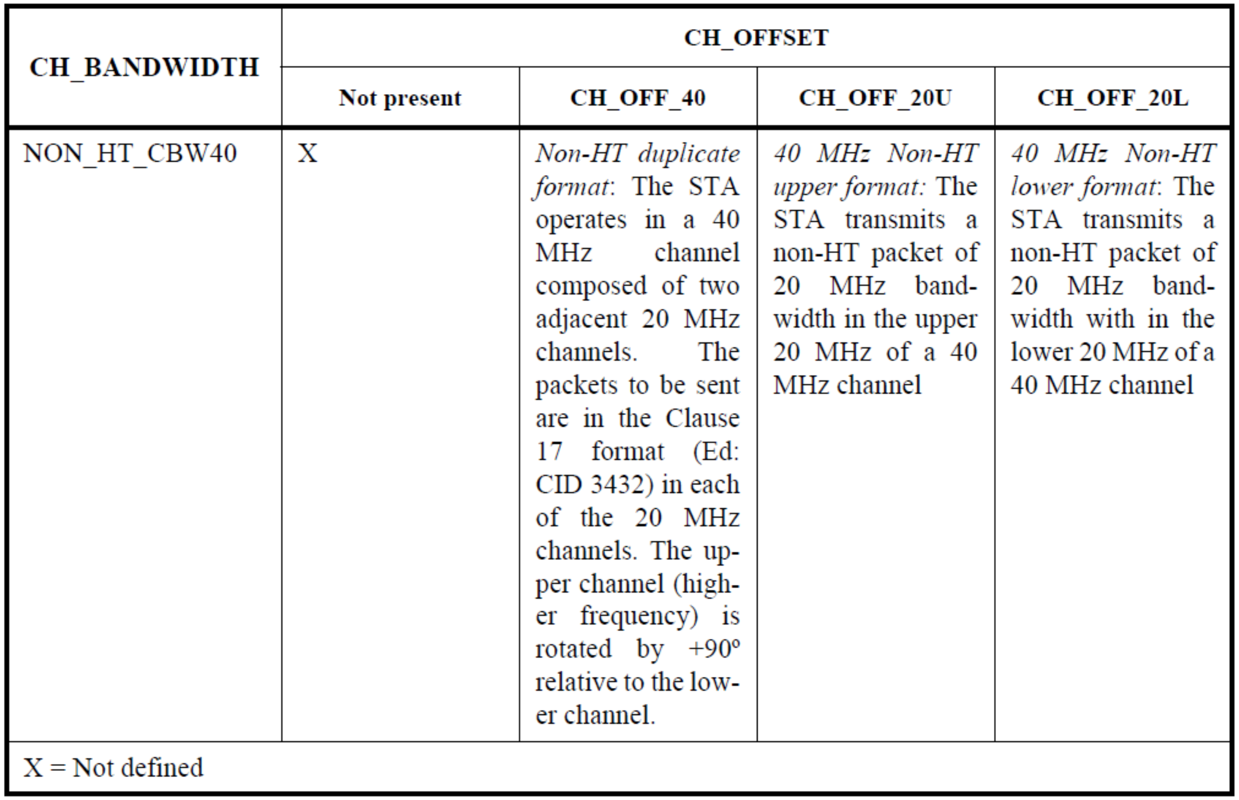


Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

CH_BANDWIDTH	**CH_OFFSET**			
	Not present	**CH_OFF_40**	**CH_OFF_20U**	**CH_OFF_20L**
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel



CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

<table>
<tr><th>Claim 7 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>NON_HT_CBW40</td><td>X</td><td>*Non-HT duplicate format*: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.</td><td>*40 MHz Non-HT upper format:* The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel</td><td>*40 MHz Non-HT lower format*: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel</td></tr>
<tr><td colspan="5">X = Not defined</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n55
</td></tr>
</table>

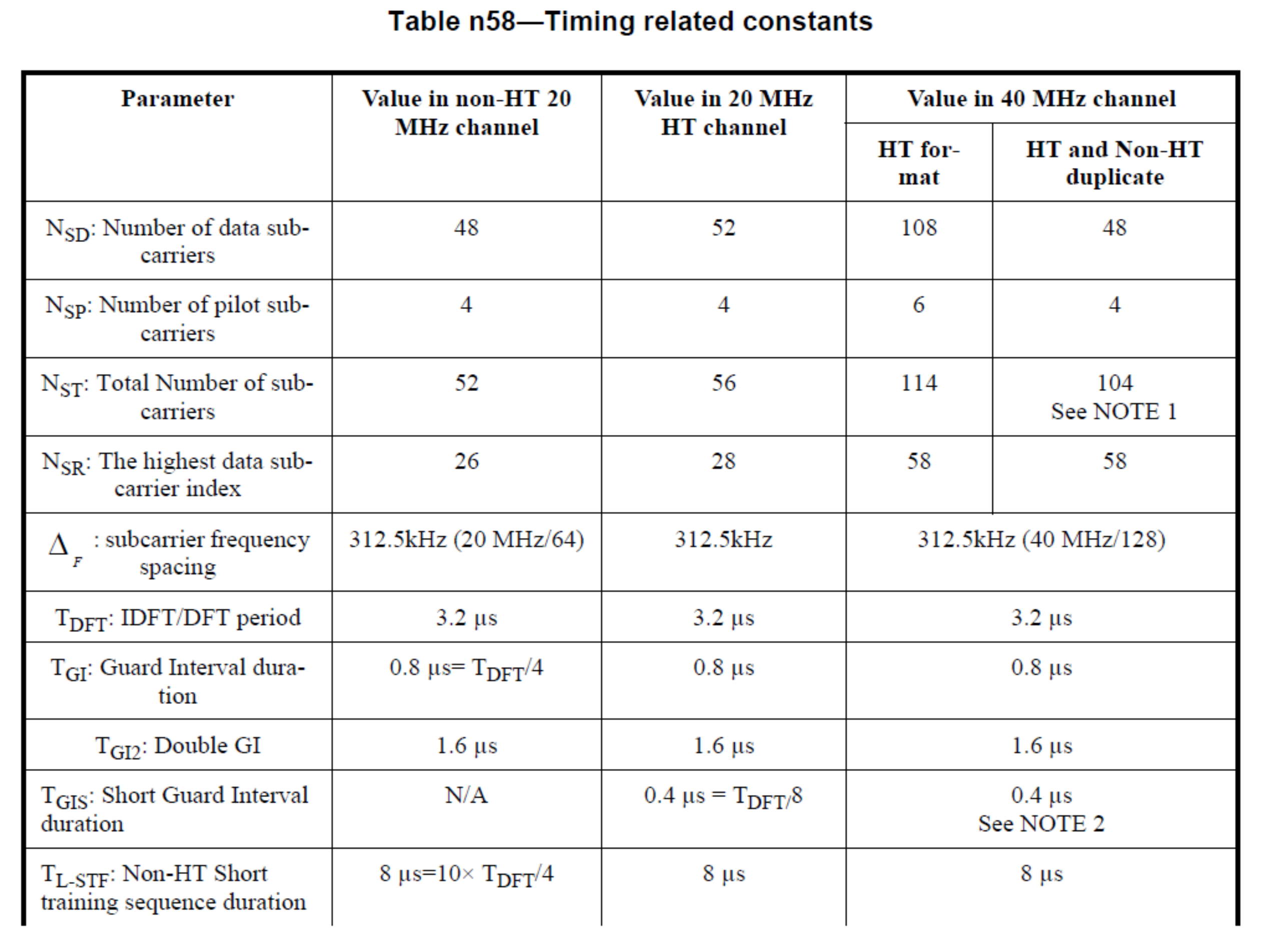
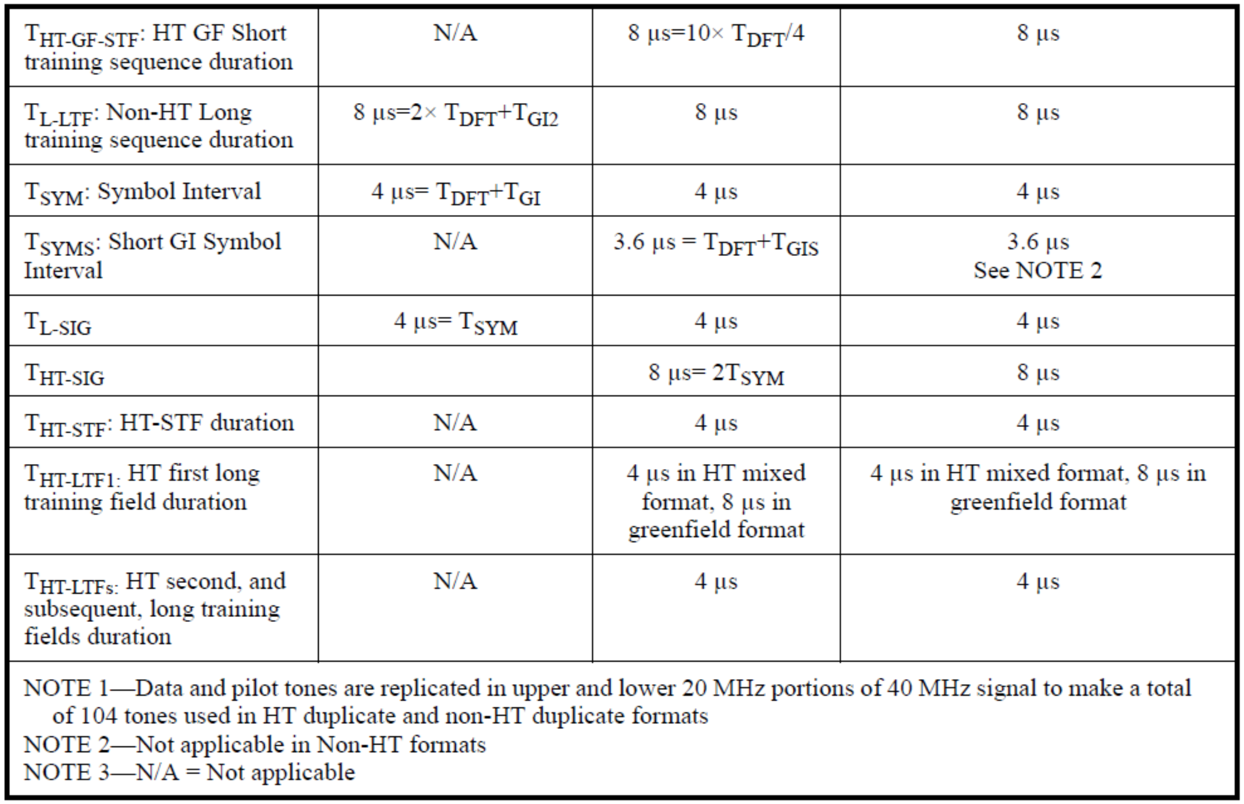
Claim 7 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	

Table n58—Timing related constants

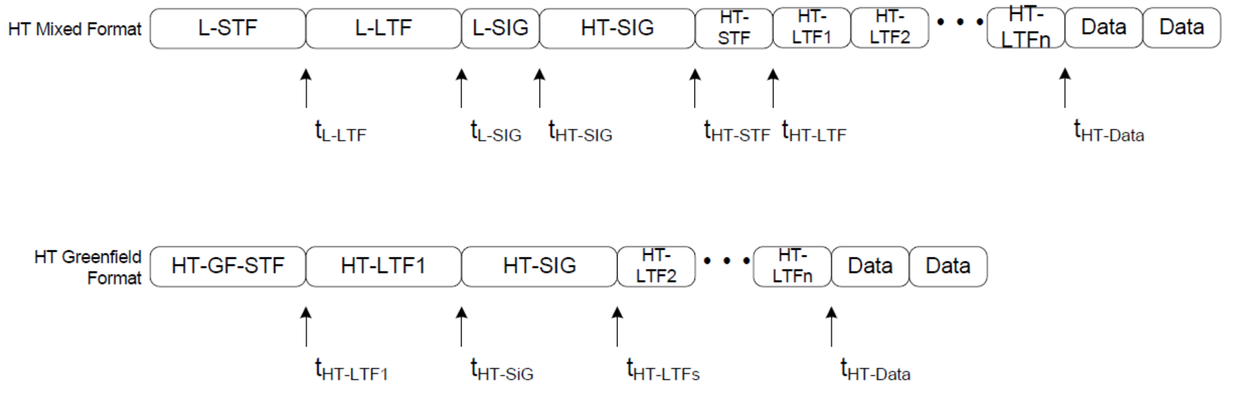
Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F: subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

Claim 7 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	

$T_{HT\text{-}GF\text{-}STF}$: HT GF Short training sequence duration	N/A	8 µs=10× T_{DFT}/4	8 µs
$T_{L\text{-}LTF}$: Non-HT Long training sequence duration	8 µs=2× T_{DFT}+T_{GI2}	8 µs	8 µs
T_{SYM}: Symbol Interval	4 µs= T_{DFT}+T_{GI}	4 µs	4 µs
T_{SYMS}: Short GI Symbol Interval	N/A	3.6 µs = T_{DFT}+T_{GIS}	3.6 µs See NOTE 2
$T_{L\text{-}SIG}$	4 µs= T_{SYM}	4 µs	4 µs
$T_{HT\text{-}SIG}$		8 µs= 2T_{SYM}	8 µs
$T_{HT\text{-}STF}$: HT-STF duration	N/A	4 µs	4 µs
$T_{HT\text{-}LTF1}$: HT first long training field duration	N/A	4 µs in HT mixed format, 8 µs in greenfield format	4 µs in HT mixed format, 8 µs in greenfield format
$T_{HT\text{-}LTFs}$: HT second, and subsequent, long training fields duration	N/A	4 µs	4 µs

NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable

See, e.g., 802.11n D2.0 Table n58

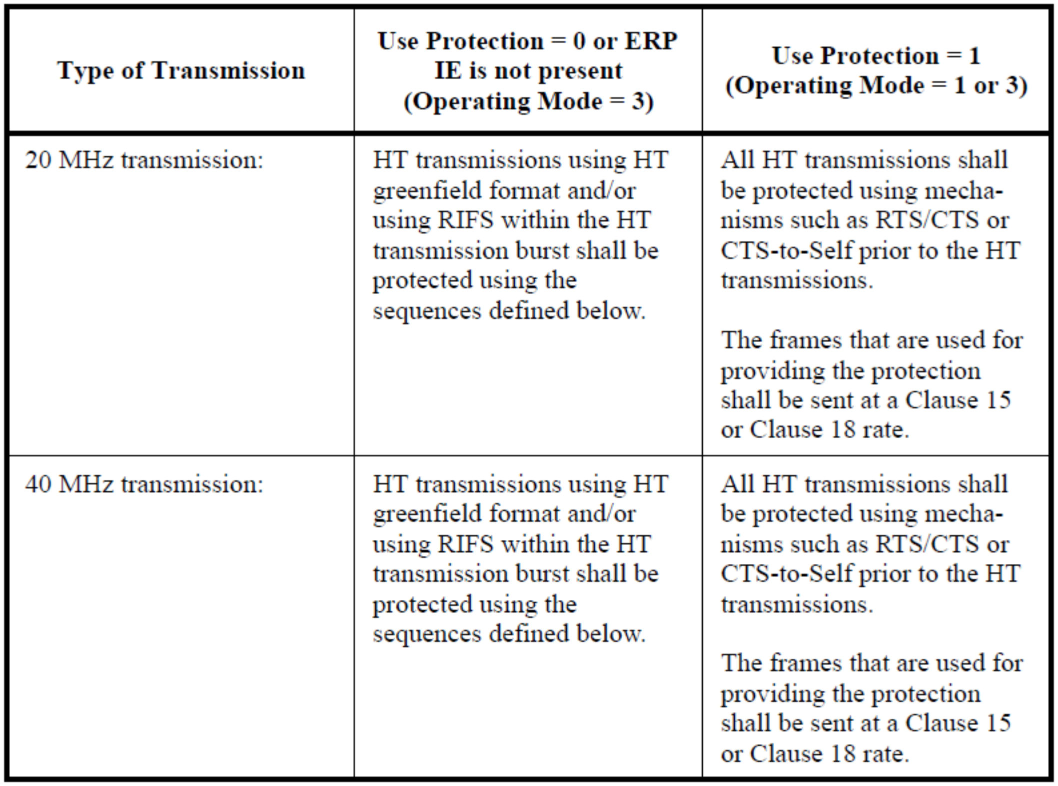
Claim 7 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.

Claim 8 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
[8.1] The method of claim 1	802.11n D2.0 discloses all the elements of claim 1 for all the reasons provided above.
[8.2] wherein the first information and the second	802.11n D2.0 discloses “wherein the first information and the second information are from the same data stream.” See, e.g.:

Claim 8 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
information are from the same data stream.	**high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19 **non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

<table>
<tr><th>Claim 8 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

Table n49—Protection requirements for Operating Modes of 1 and 3

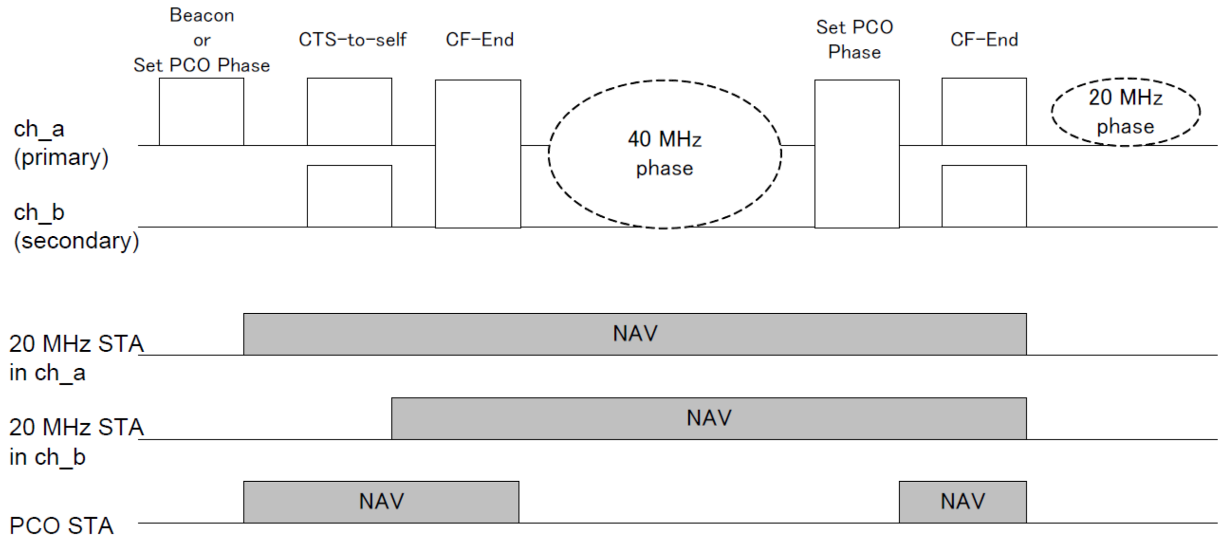


<table>
<tr><th>Type of Transmission</th><th>Use Protection = 0 or ERP IE is not present (Operating Mode = 3)</th><th>Use Protection = 1 (Operating Mode = 1 or 3)</th></tr>
<tr><td>20 MHz transmission:</td><td>HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.</td><td>All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions.
The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.</td></tr>
<tr><td>40 MHz transmission:</td><td>HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.</td><td>All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions.
The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.</td></tr>
</table>

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.
NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).

</td></tr>
</table>

Claim 8 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

Claim 8 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

Claim 8 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 8 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

<table>
<tr><th>Claim 8 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details.

See, e.g., 802.11n D2.0 § 20.3.4.s

Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied.

See, e.g., 802.11n D2.0 § 20.3.4.t

20.3.22 PLCP transmit procedure
There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters).

A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters).

The PLCP shall issue the parameters in the following PMD primitives to configure the PHY:
— PMD_TXPWRLVL
— PMD_TX_PARAMETERS
— PMD_EXPANSIONS_MAT
— PMD_EXPANSIONS_MAT_ON</td></tr>
</table>

Claim 8 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

Claim 8 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $$r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t\right)\right\} \qquad (20\text{-}1)$$ where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

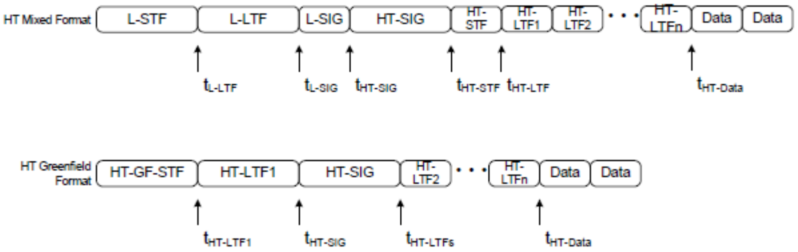


Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) \;=\; & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right) T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \quad (20\text{-}2)$$

where

$t_{L-LTF} = T_{L-STF}$

$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$

$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$

$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$r_{PPDU}^{(i_{TX})}(t) = r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1})$$

$$+ r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG})$$

$$+ \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2)T_{HT-LTFs})$$

$$+ r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \quad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\text{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\text{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j2\pi k \Delta_F t) \quad (20\text{-}4)$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \quad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \quad (20\text{-}6)$$

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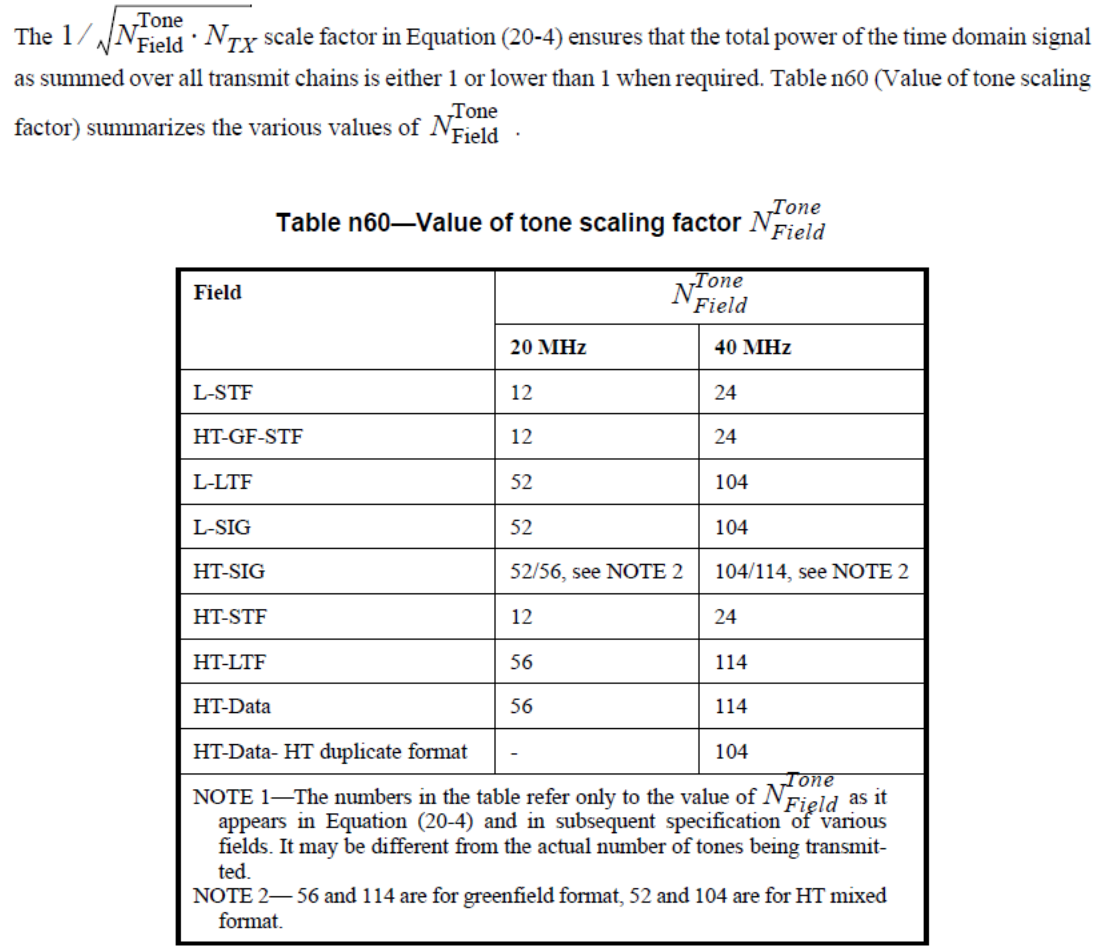


The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	40 MHz
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

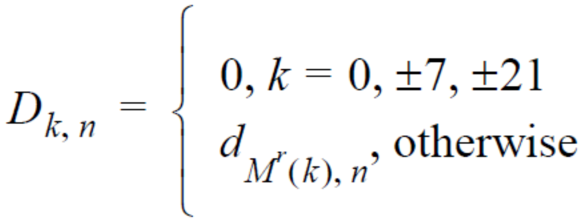
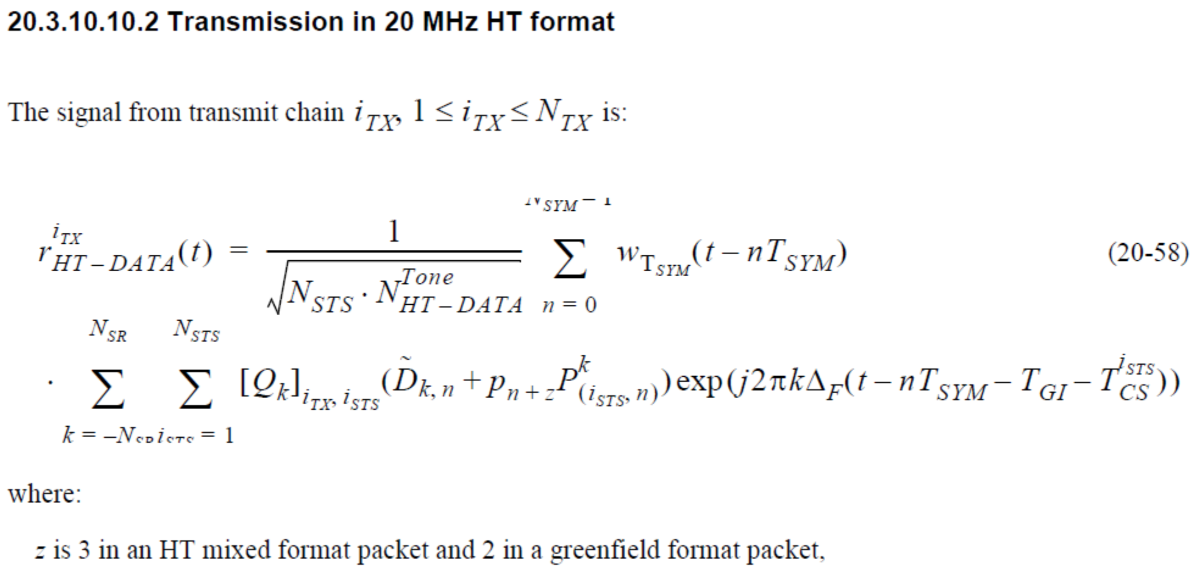
NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

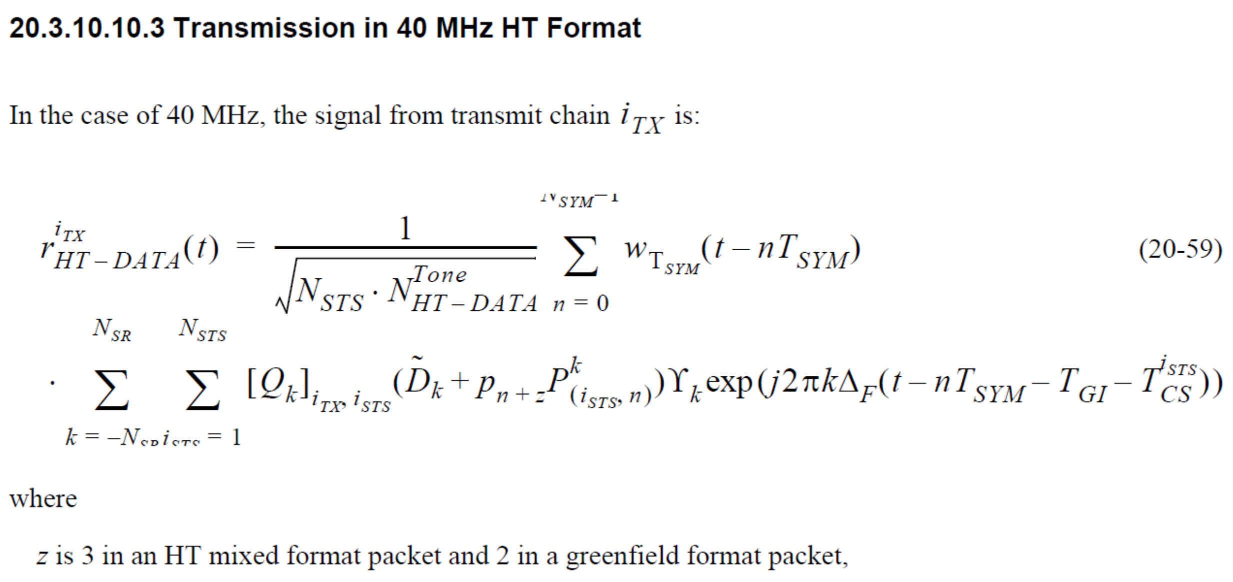
NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

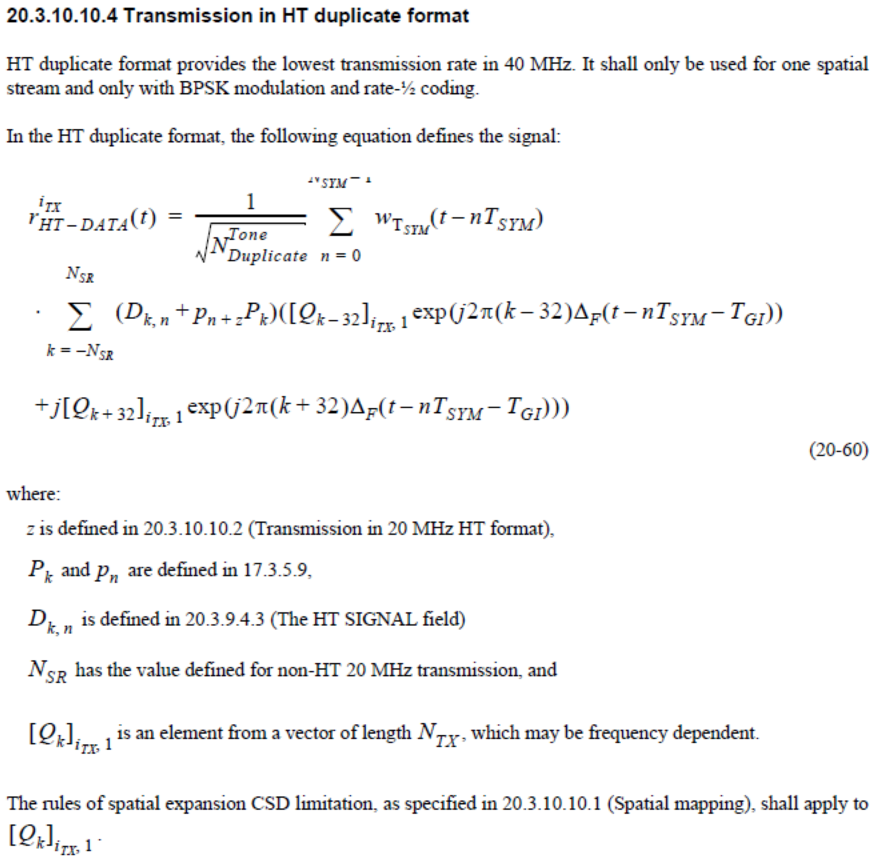
See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

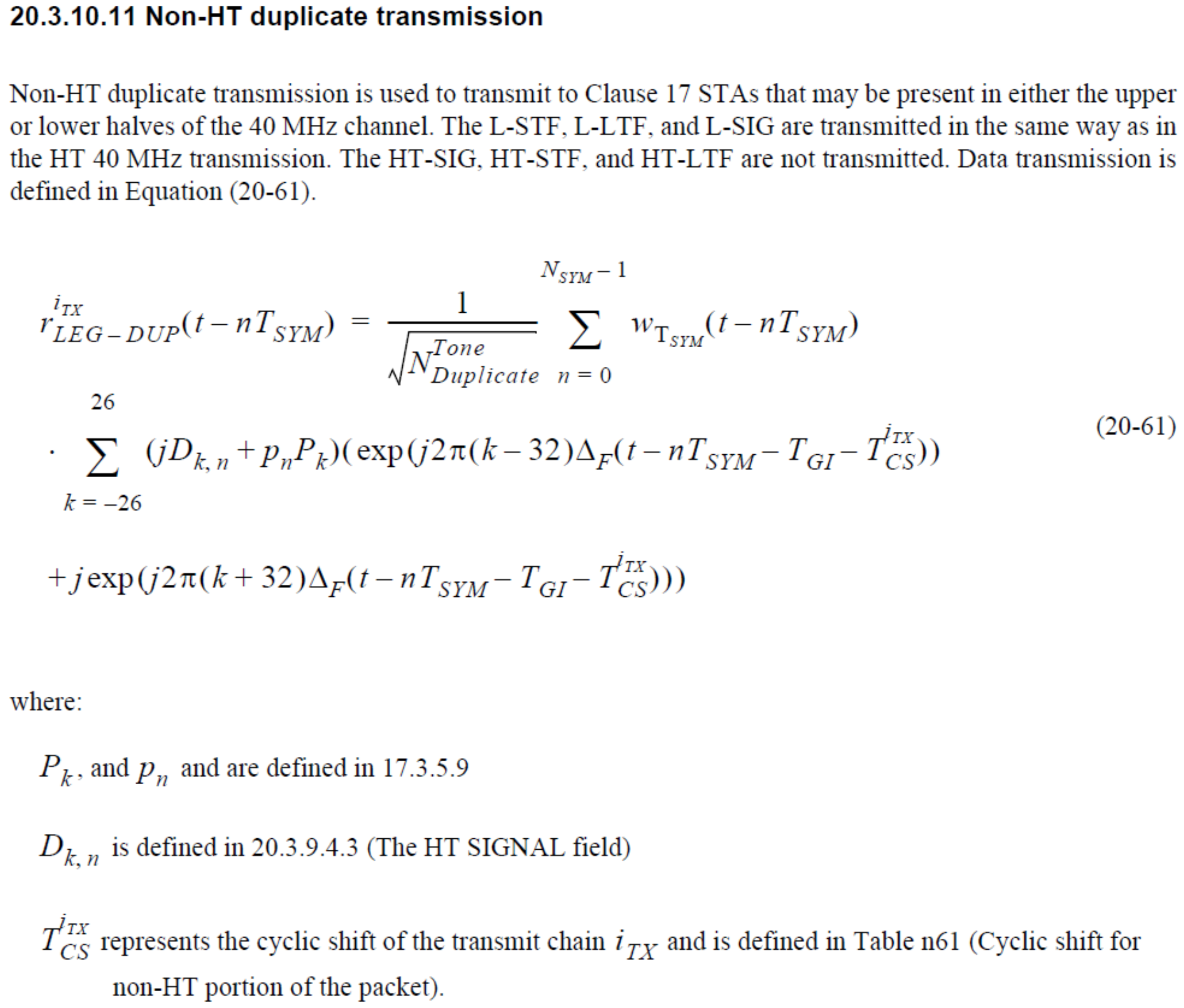
20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

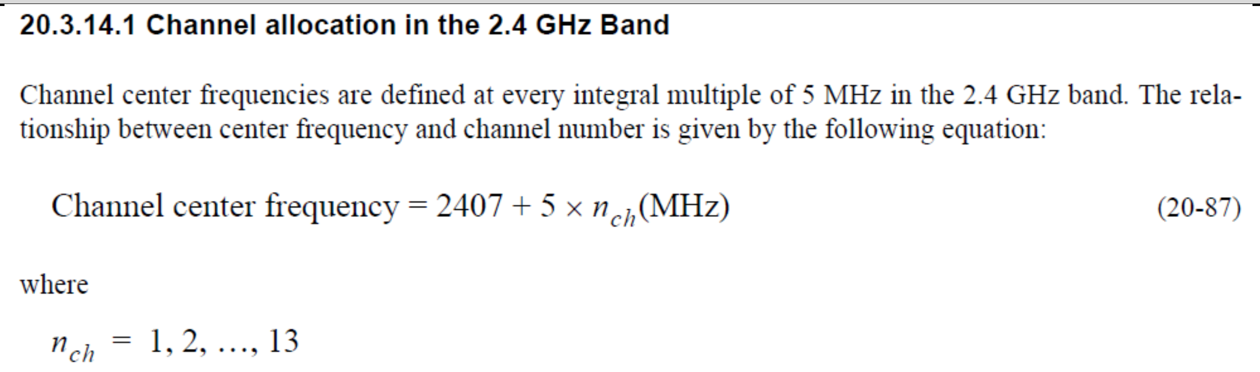
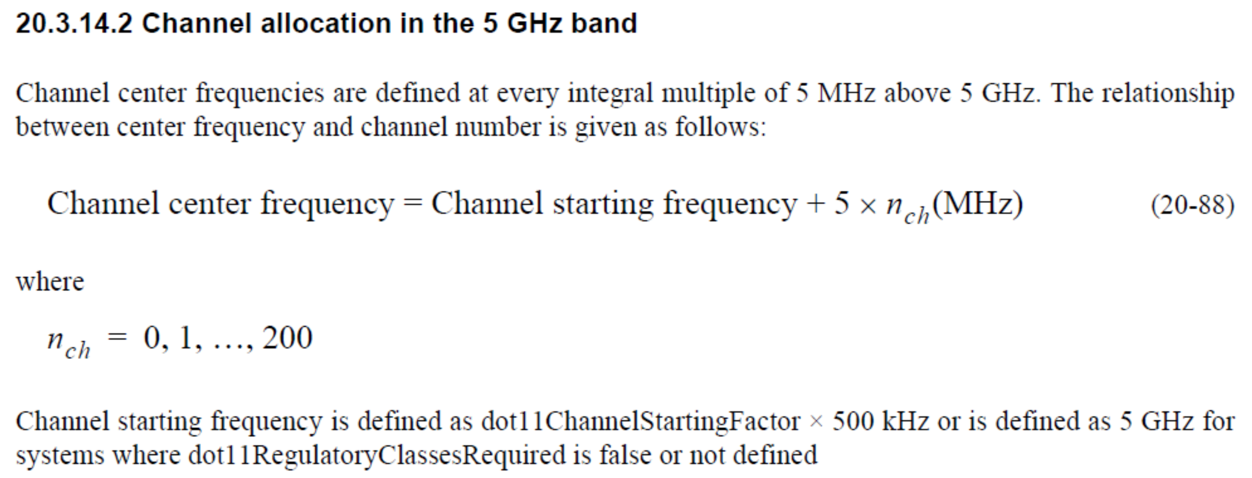
When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

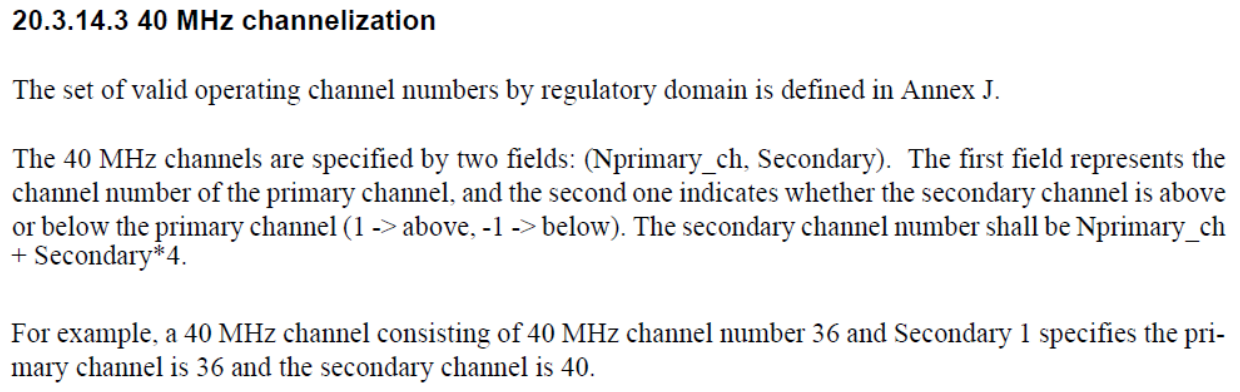
Claim 8 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{\mathrm{T}_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P_{(i_{STS},n)}^{k}) \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (20-58) where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

Claim 8 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P_{(i_{STS}, n)}^{k}) \Upsilon_k \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (20-59) where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

Claim 8 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n}+p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1}\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI})) + j[Q_{k+32}]_{i_{TX},1}\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

Claim 8 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r^{i_{TX}}_{LEG-DUP}(t-nT_{SYM}) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n}+p_nP_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T^{i_{TX}}_{CS}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 8 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz}) \quad (20\text{-}87)$ where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz}) \quad (20\text{-}88)$ where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 8 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

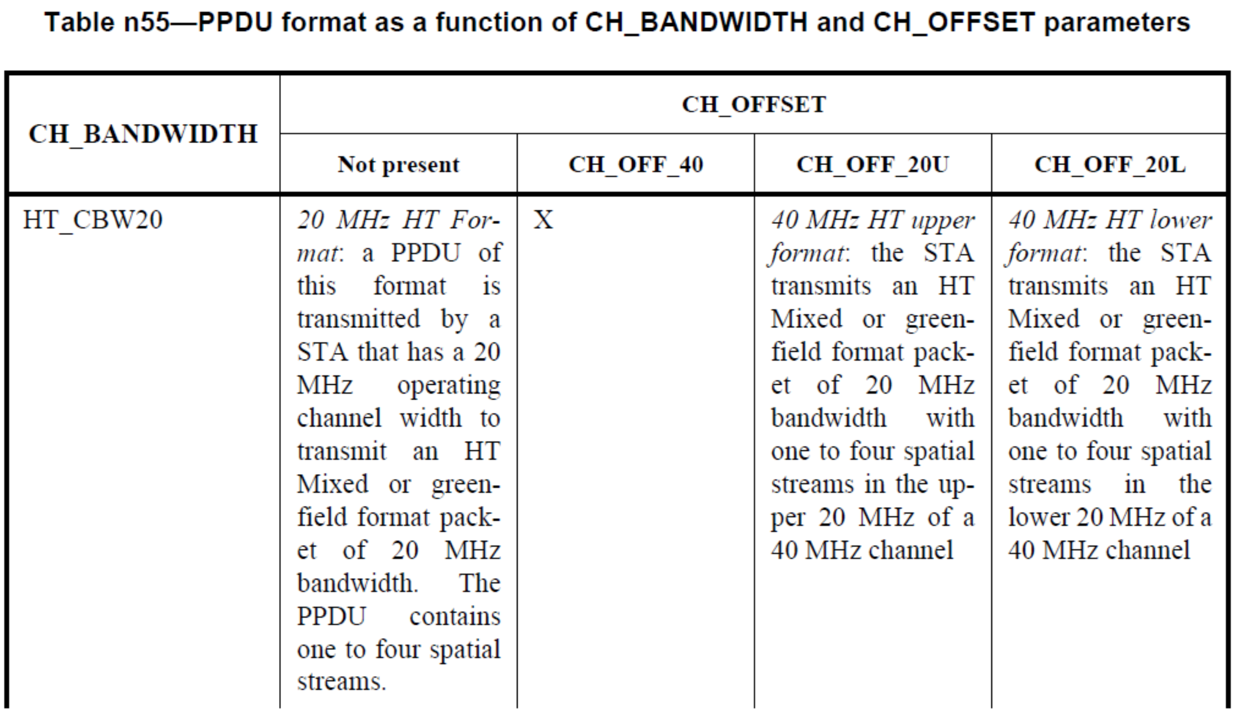
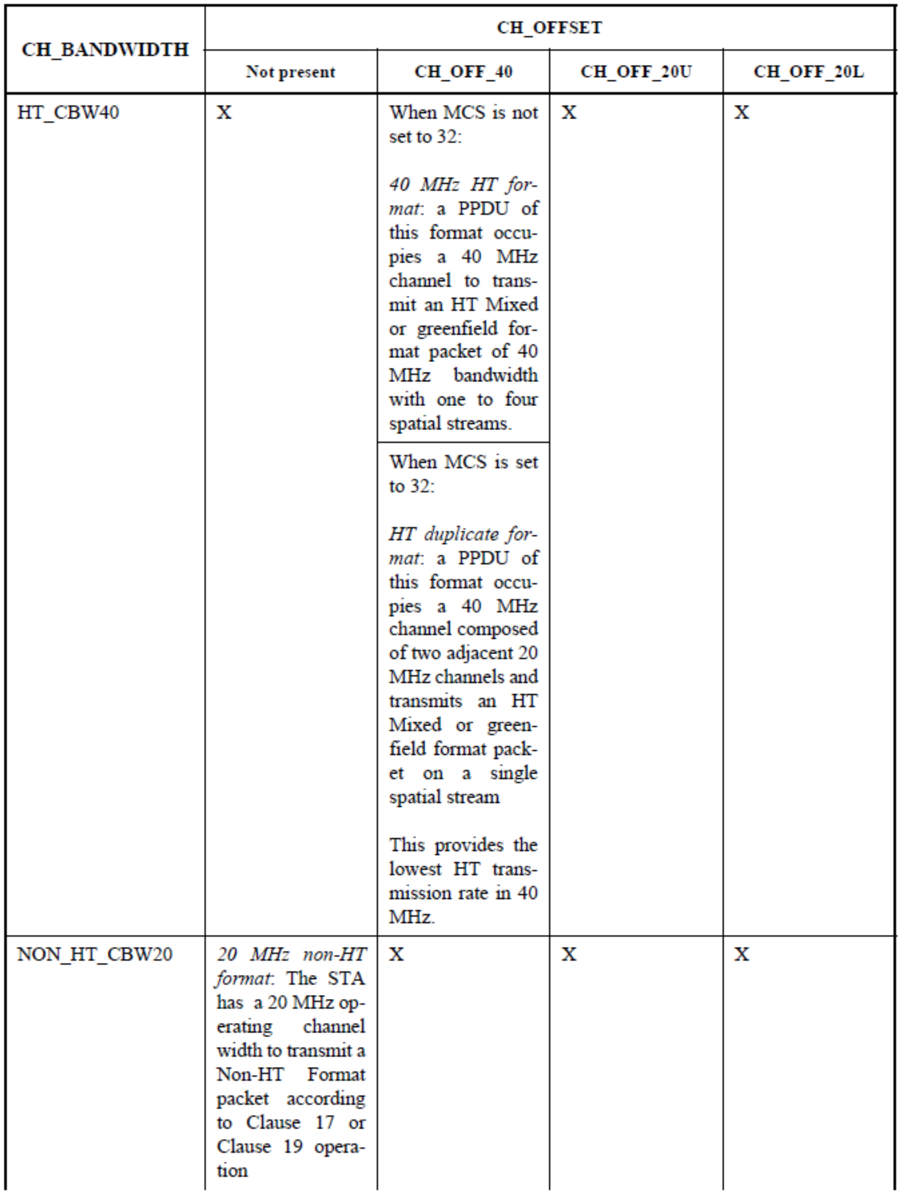
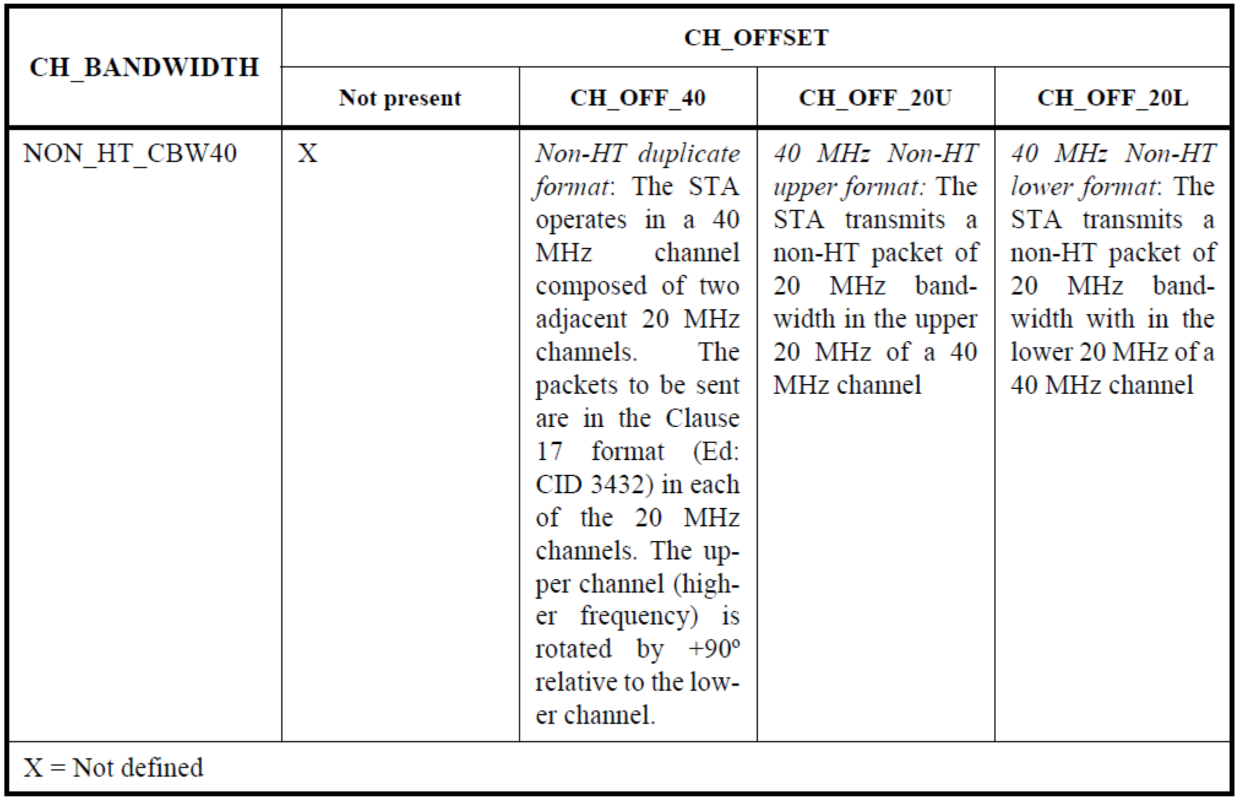
Claim 8 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.20.3 

Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel



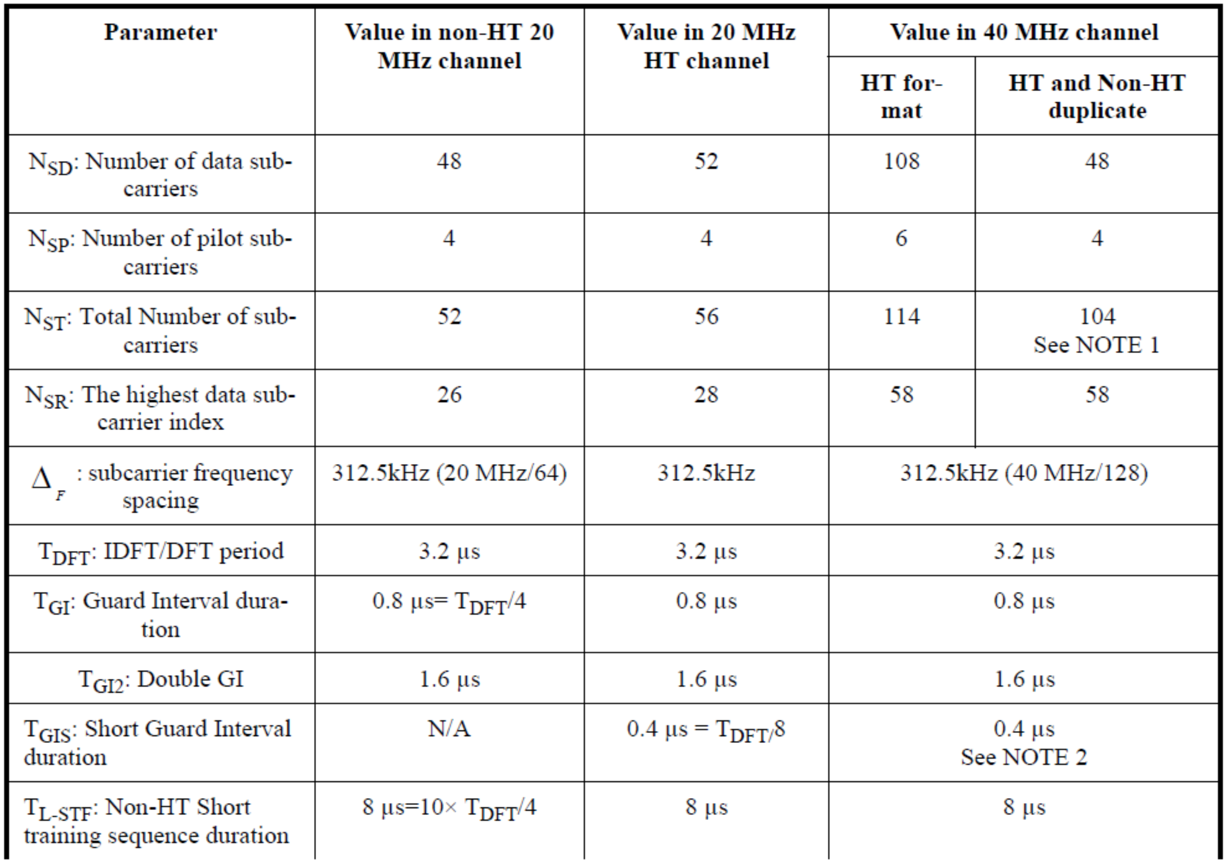
CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

Claim 8 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 See, e.g., 802.11n D2.0 Table n55

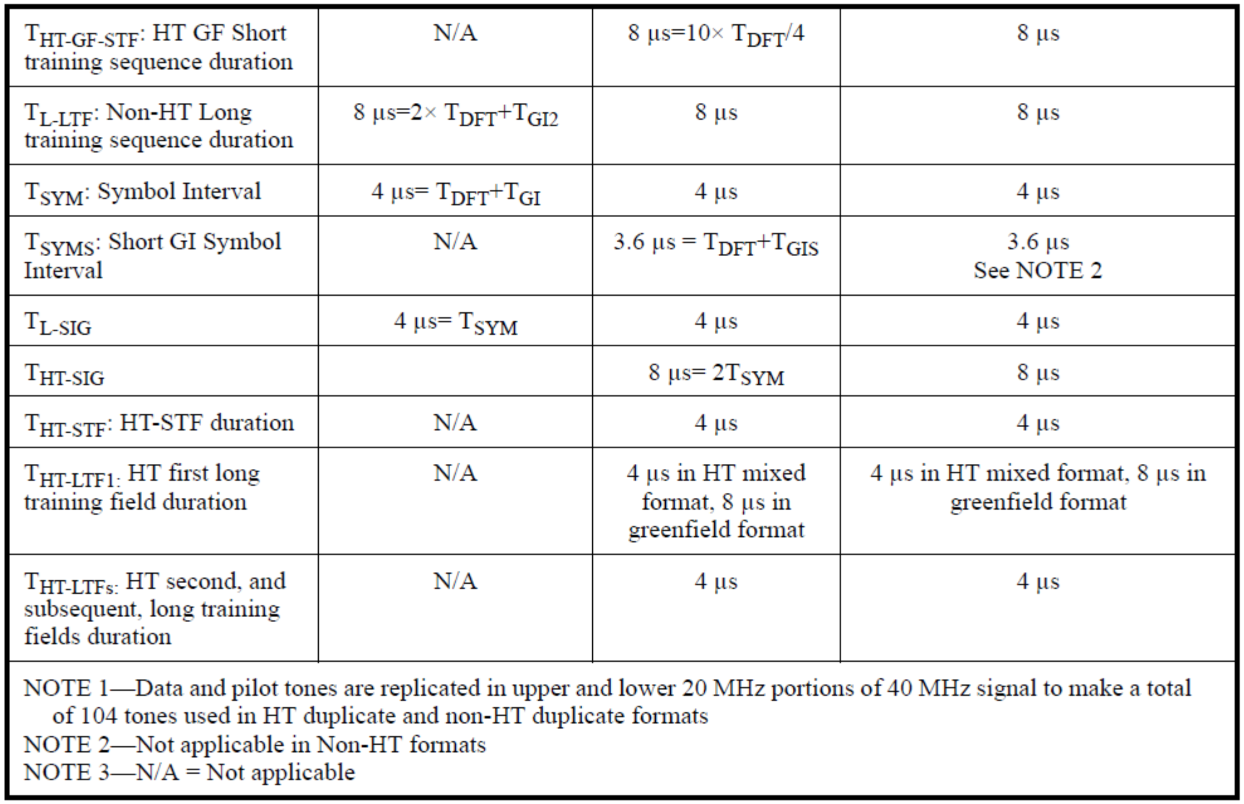
CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
NON_HT_CBW40	X	*Non-HT duplicate format*: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.	*40 MHz Non-HT upper format:* The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel	*40 MHz Non-HT lower format*: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel
X = Not defined				

Claim 8 of the ’802 Patent	Prior Art Reference – 802.11n D2.0

Table n58—Timing related constants



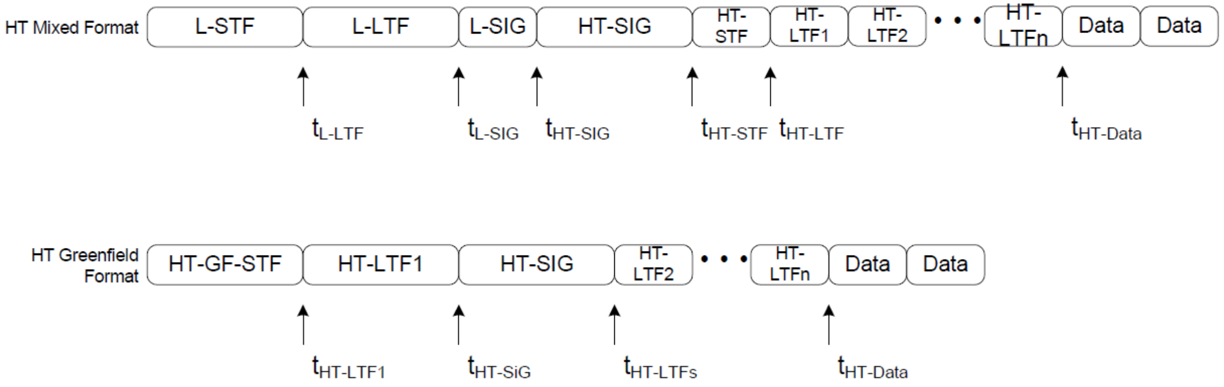
Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

Claim 8 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	

$T_{HT\text{-}GF\text{-}STF}$: HT GF Short training sequence duration	N/A	8 μs=10× $T_{DFT}/4$	8 μs
$T_{L\text{-}LTF}$: Non-HT Long training sequence duration	8 μs=2× $T_{DFT}+T_{GI2}$	8 μs	8 μs
T_{SYM}: Symbol Interval	4 μs= $T_{DFT}+T_{GI}$	4 μs	4 μs
T_{SYMS}: Short GI Symbol Interval	N/A	3.6 μs = $T_{DFT}+T_{GIS}$	3.6 μs See NOTE 2
$T_{L\text{-}SIG}$	4 μs= T_{SYM}	4 μs	4 μs
$T_{HT\text{-}SIG}$		8 μs= $2T_{SYM}$	8 μs
$T_{HT\text{-}STF}$: HT-STF duration	N/A	4 μs	4 μs
$T_{HT\text{-}LTF1}$: HT first long training field duration	N/A	4 μs in HT mixed format, 8 μs in greenfield format	4 μs in HT mixed format, 8 μs in greenfield format
$T_{HT\text{-}LTFs}$: HT second, and subsequent, long training fields duration	N/A	4 μs	4 μs

NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable

See, e.g., 802.11n D2.0 Table n58

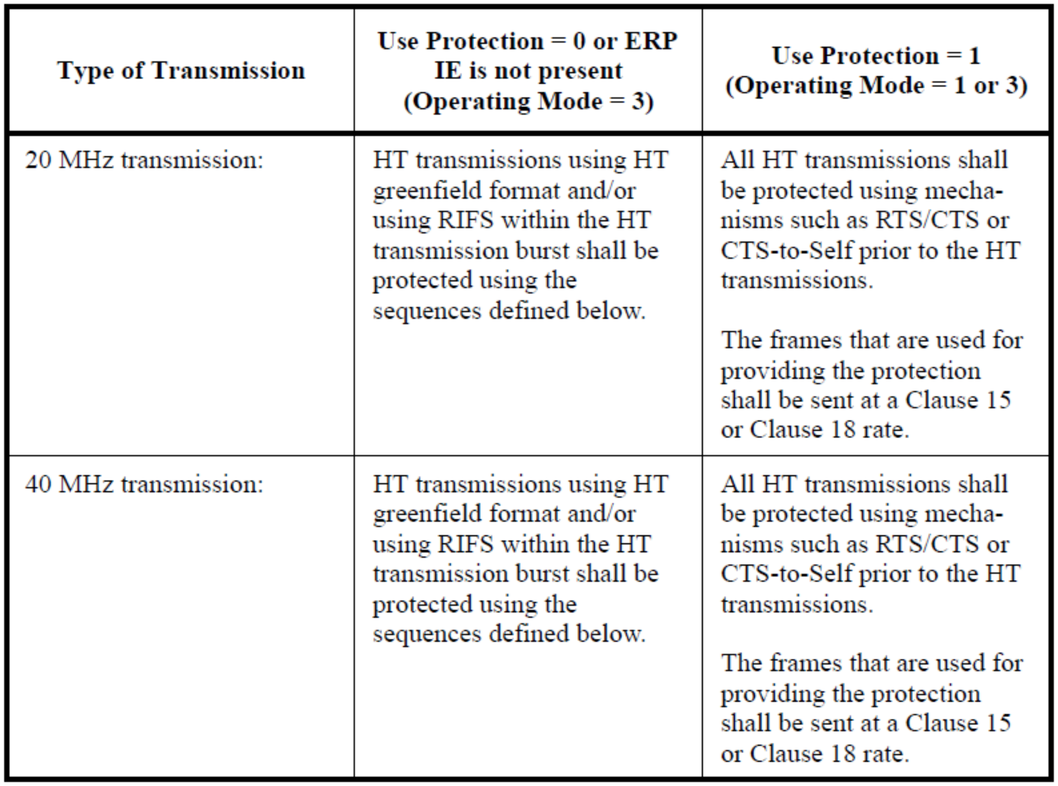
Claim 8 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.

Claim 9 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
[9.1] The method of claim 1	802.11n D2.0 discloses all the elements of claim 1 for all the reasons provided above.
[9.2] wherein first information and second information comprise a plurality of OFDM	802.11n D2.0 discloses “wherein first information and second information comprise a plurality of OFDM symbols, wherein a first symbol is transmitted during a first time slot across the first frequency range and a second symbol is transmitted during the first time slot across the second

Claim 9 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
symbols, wherein a first symbol is transmitted during a first time slot across the first frequency range and a second symbol is transmitted during the first time slot across the second frequency range, and wherein a third symbol is transmitted during a second time slot across the first frequency range and a fourth symbol is transmitted during the second time slot across a second frequency range.	frequency range, and wherein a third symbol is transmitted during a second time slot across the first frequency range and a fourth symbol is transmitted during the second time slot across a second frequency range.” See, e.g.: **high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19 **non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that

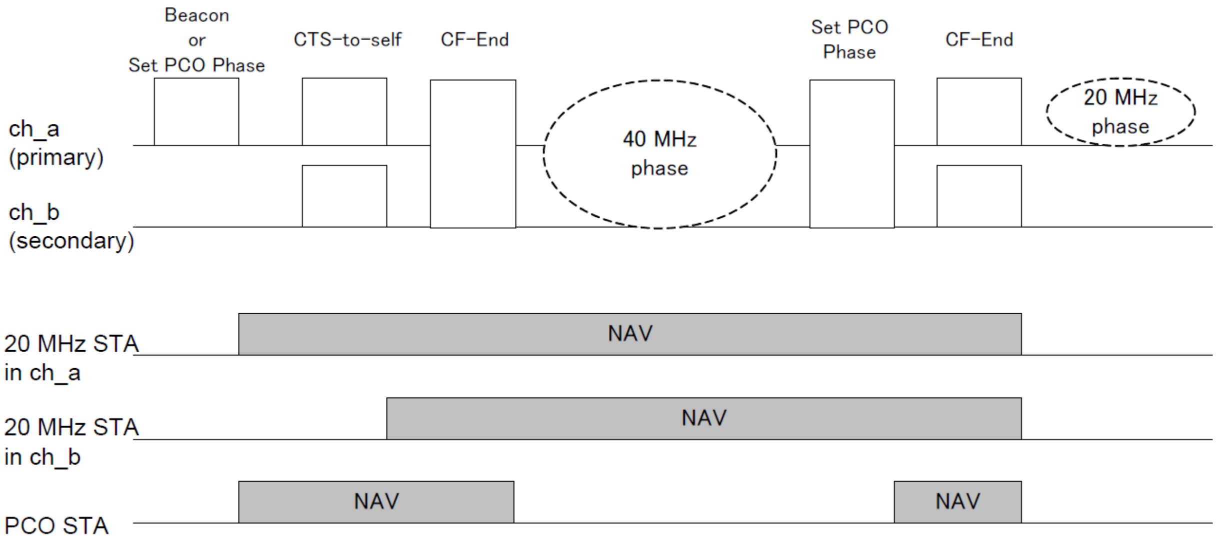
<table>
<tr><th>Claim 9 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>
is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

Table n49—Protection requirements for Operating Modes of 1 and 3


<table>
<tr><th>Type of Transmission</th><th>Use Protection = 0 or ERP IE is not present (Operating Mode = 3)</th><th>Use Protection = 1 (Operating Mode = 1 or 3)</th></tr>
<tr><td>20 MHz transmission:</td><td>HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.</td><td>All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions.
The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.</td></tr>
<tr><td>40 MHz transmission:</td><td>HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.</td><td>All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions.
The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.</td></tr>
</table>

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
</td></tr>
</table>

Claim 9 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20. NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames). b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

Claim 9 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

Claim 9 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 9 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format[1] and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. [1] The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to $N_{SD}-1$ and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

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	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

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	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

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	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t \right) \right\}$ (20-1) where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

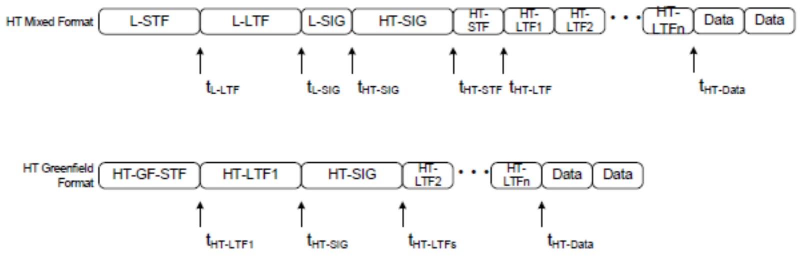

Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) \;=\;& r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ &+ r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ &+ r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ &+ r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ &+ \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right)T_{HT-LTFs}\right) \\ &+ r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \qquad (20\text{-}2)$$

where

$t_{L-LTF} = T_{L-STF}$

$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$

$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$

$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1}) \\ & + r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2) T_{HT-LTFs}) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \tag{20-3}$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\text{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\text{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j 2\pi k \Delta_F t) \tag{20-4}$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \tag{20-5}$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \tag{20-6}$$

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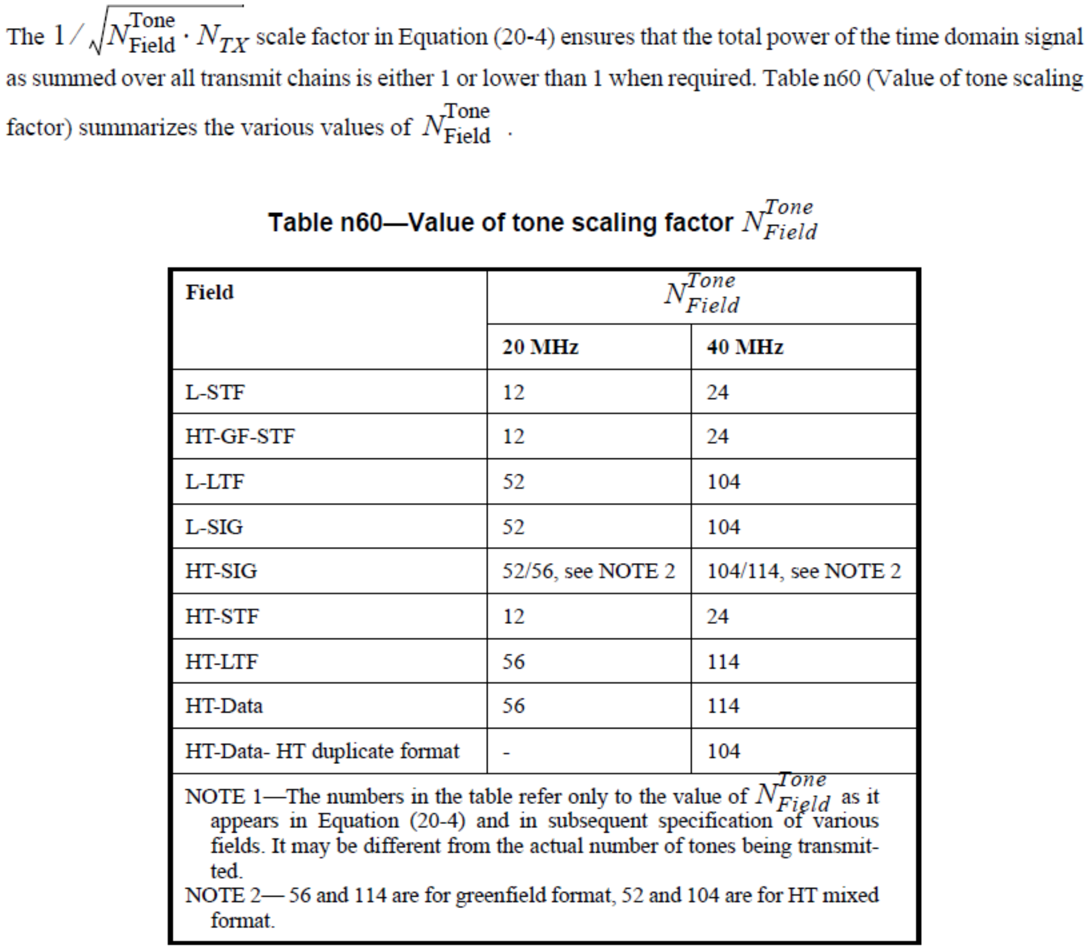

The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	**40 MHz**
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

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	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS} \cdot N^{Tone}_{HT-DATA}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM})$ (20-58) $\cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P^k_{(i_{STS}, n)}) \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T^{i_{STS}}_{CS}))$ where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

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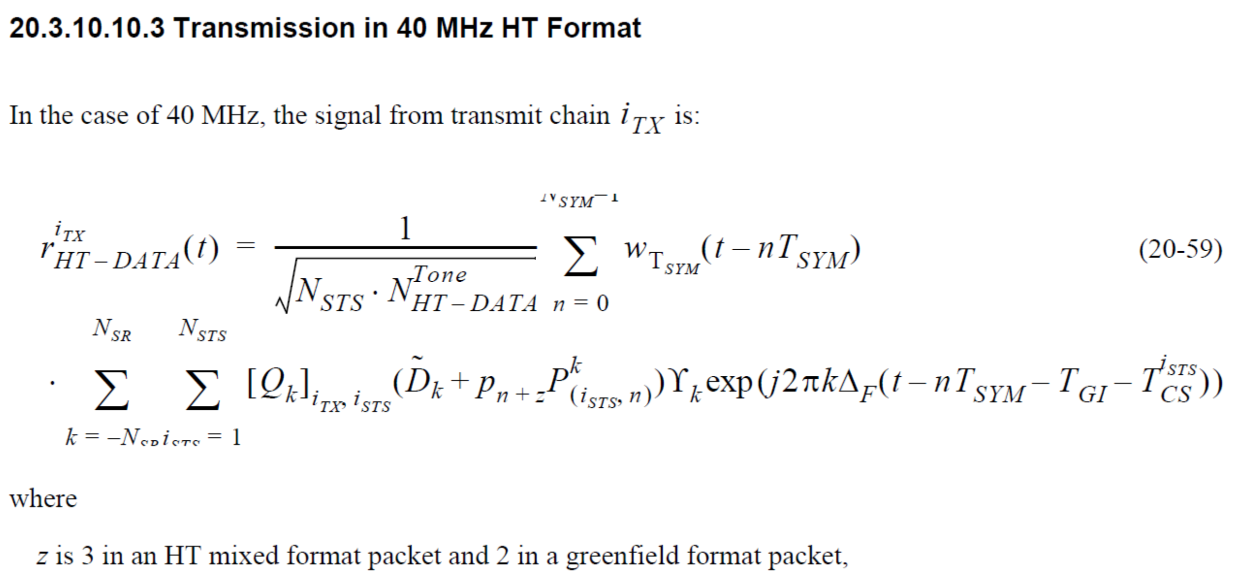
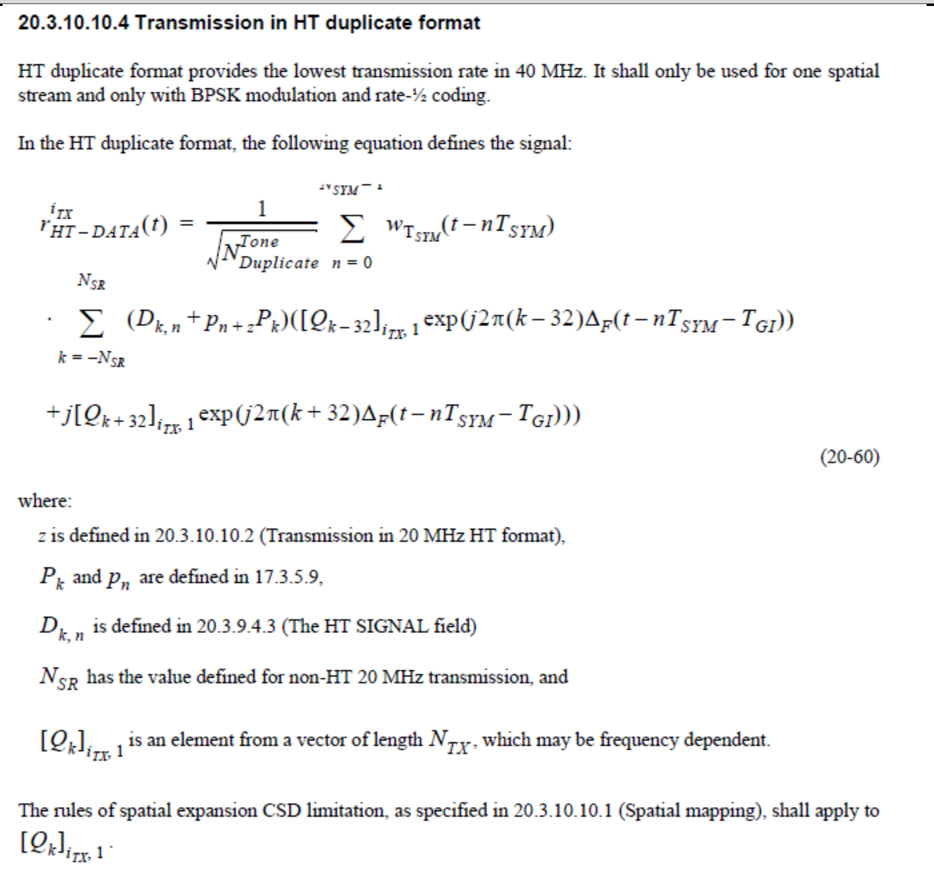
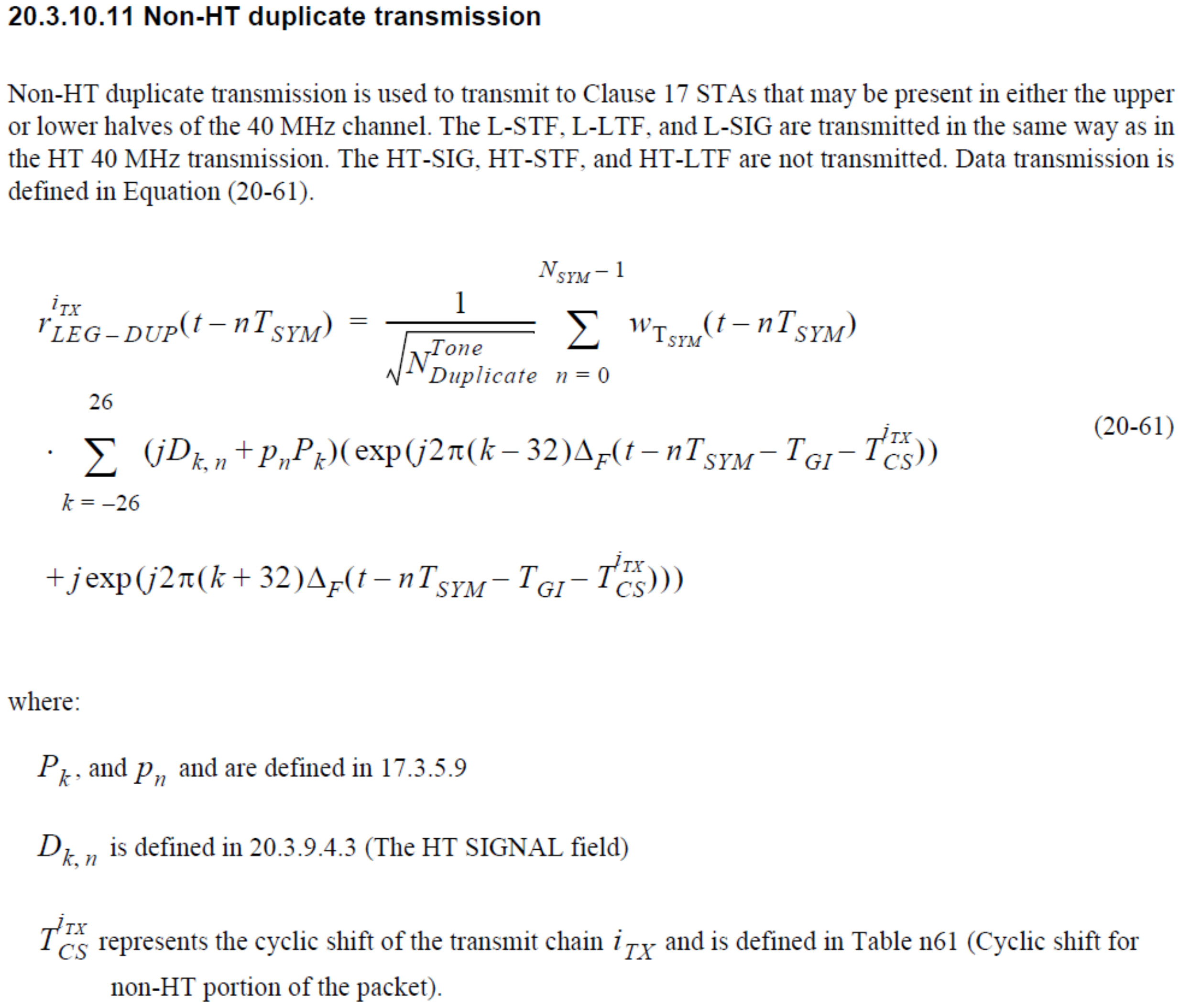
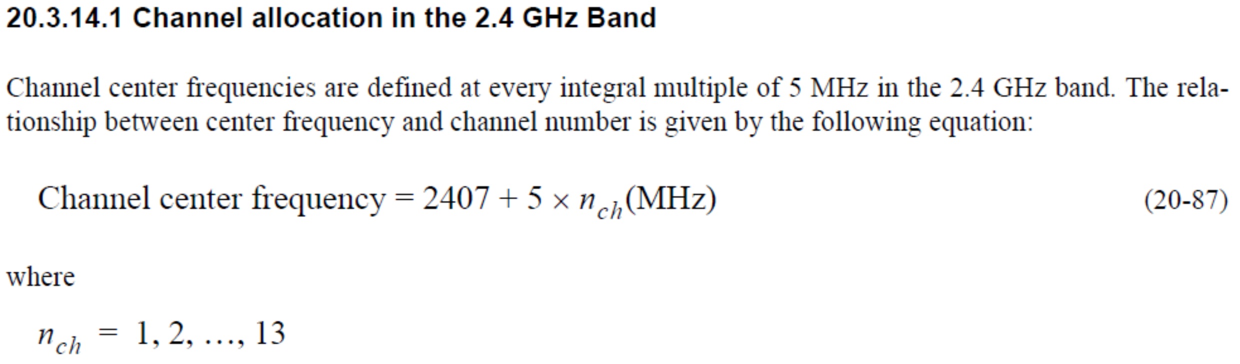
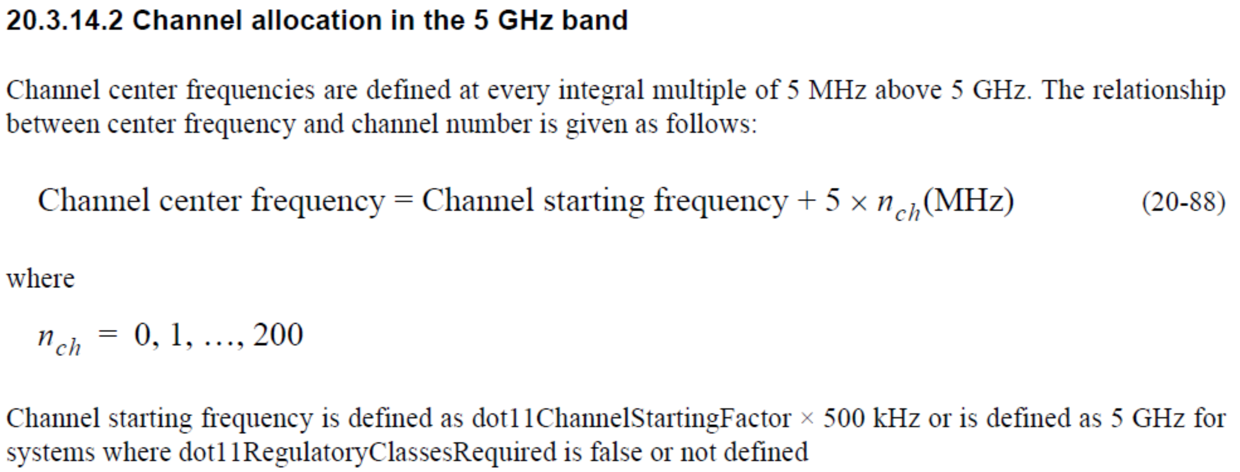
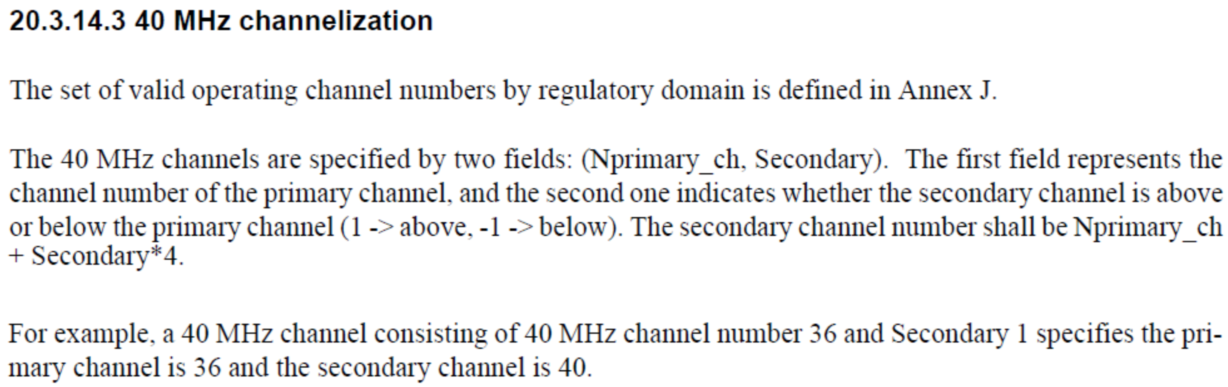
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P_{(i_{STS}, n)}^{k}) \Upsilon_k \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (20-59) where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

Claim 9 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n}+p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI})) + j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

Claim 9 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r^{i_{TX}}_{LEG-DUP}(t-nT_{SYM}) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n}+p_nP_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T^{i_{TX}}_{CS}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 9 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz})$ (20-87) where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz})$ (20-88) where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 9 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

Claim 9 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.20.3

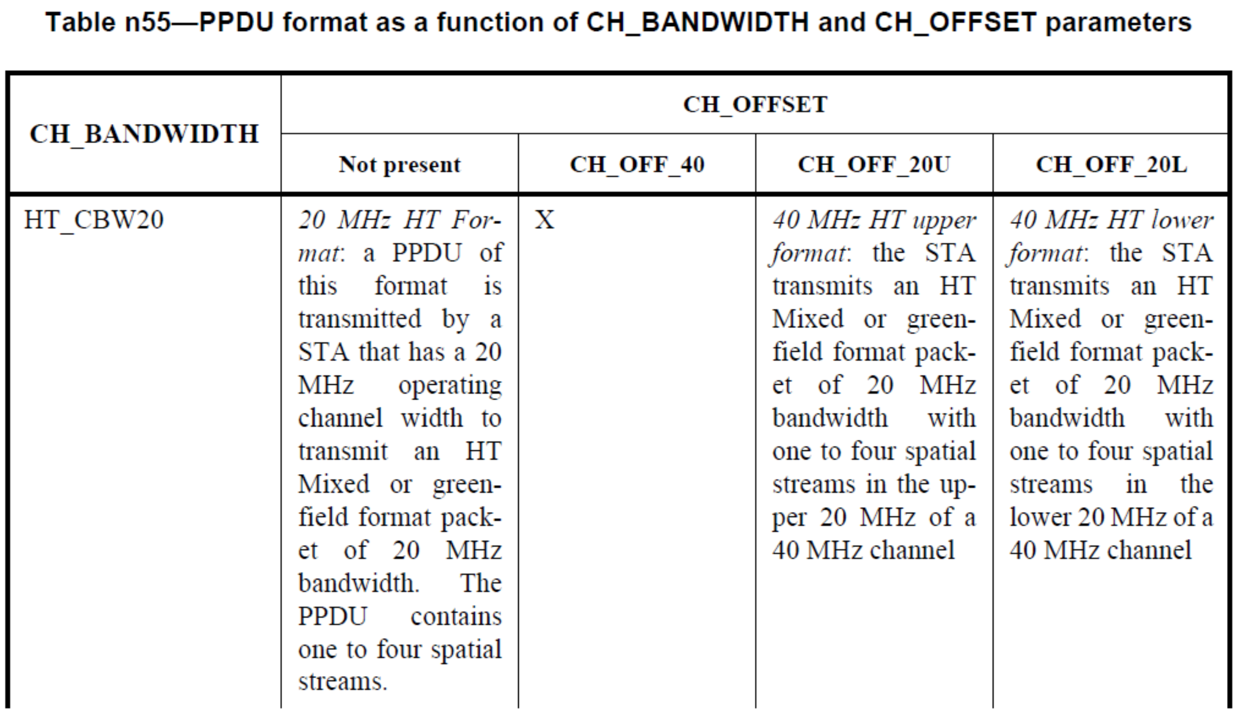
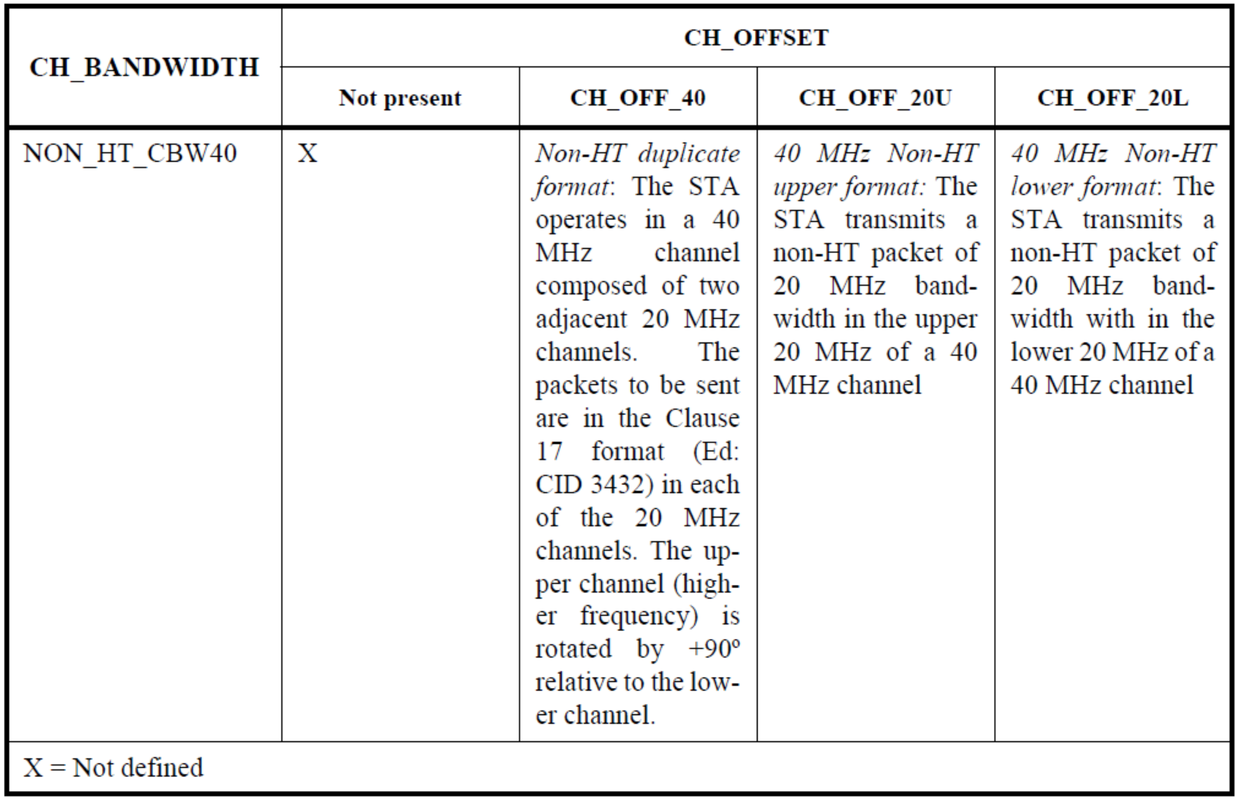


Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or green-field format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or green-field format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or green-field format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel

CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams.	X	X
		When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.		
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

<table>
<tr><th>Claim 9 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>NON_HT_CBW40</td><td>X</td><td><i>Non-HT duplicate format</i>: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.</td><td><i>40 MHz Non-HT upper format:</i> The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel</td><td><i>40 MHz Non-HT lower format</i>: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel</td></tr>
<tr><td colspan="5">X = Not defined</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n55
</td></tr>
</table>

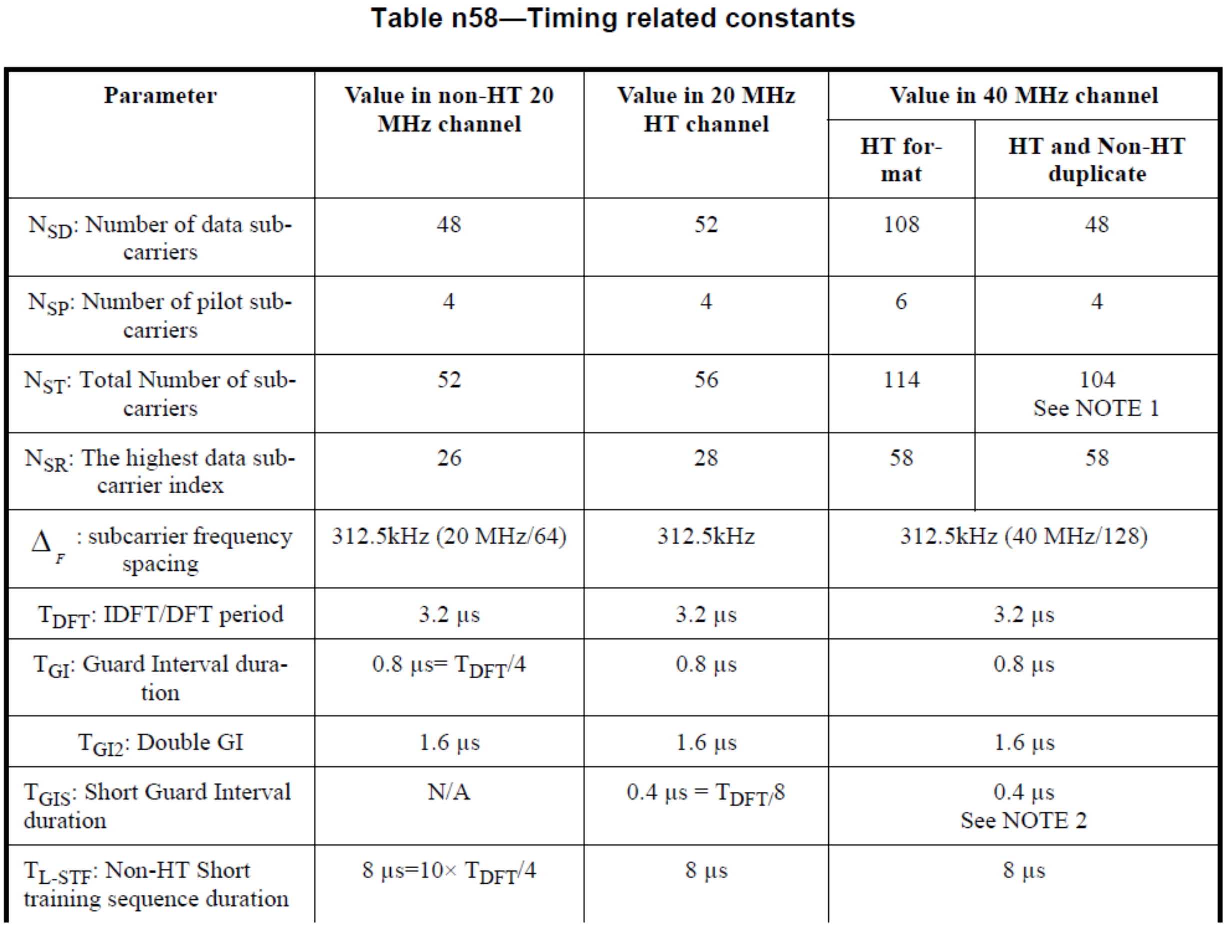
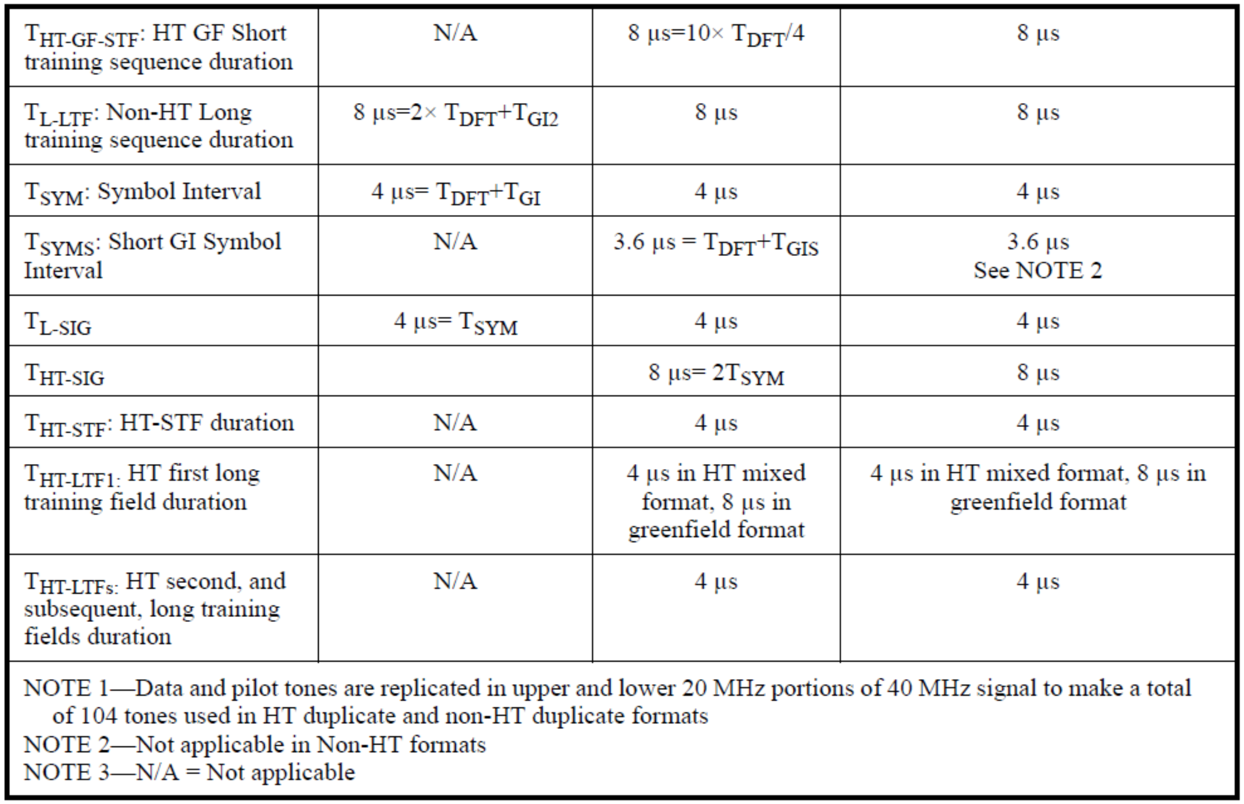
Claim 9 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	

Table n58—Timing related constants

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F: subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

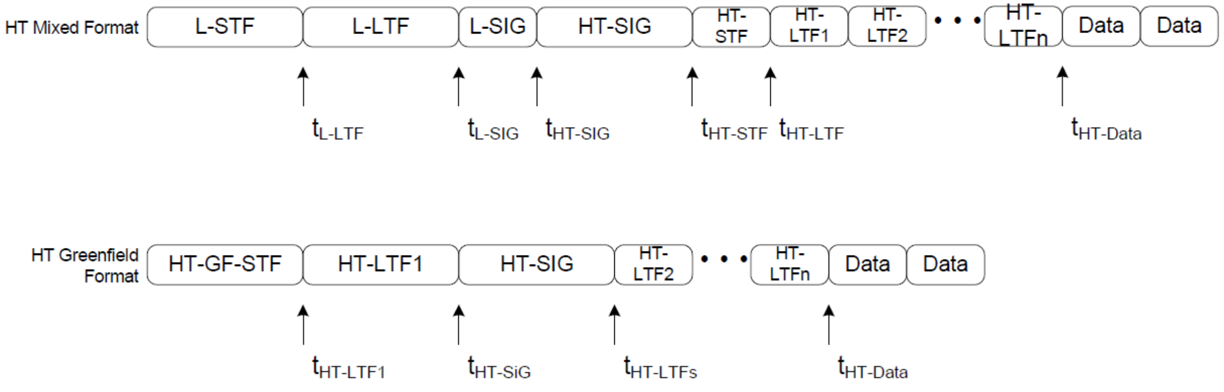
Claim 9 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	See table below



$T_{HT\text{-}GF\text{-}STF}$: HT GF Short training sequence duration	N/A	8 µs=10× T_{DFT}/4	8 µs
$T_{L\text{-}LTF}$: Non-HT Long training sequence duration	8 µs=2× $T_{DFT}+T_{GI2}$	8 µs	8 µs
T_{SYM}: Symbol Interval	4 µs= $T_{DFT}+T_{GI}$	4 µs	4 µs
T_{SYMS}: Short GI Symbol Interval	N/A	3.6 µs = $T_{DFT}+T_{GIS}$	3.6 µs See NOTE 2
$T_{L\text{-}SIG}$	4 µs= T_{SYM}	4 µs	4 µs
$T_{HT\text{-}SIG}$		8 µs= 2T_{SYM}	8 µs
$T_{HT\text{-}STF}$: HT-STF duration	N/A	4 µs	4 µs
$T_{HT\text{-}LTF1}$: HT first long training field duration	N/A	4 µs in HT mixed format, 8 µs in greenfield format	4 µs in HT mixed format, 8 µs in greenfield format
$T_{HT\text{-}LTFs}$: HT second, and subsequent, long training fields duration	N/A	4 µs	4 µs

NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable

See, e.g., 802.11n D2.0 Table n58

Claim 9 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.

Claim 10 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
[10.1] A method of transmitting information in a	To the extent the preamble is limiting, 802.11n D2.0 discloses “A method of transmitting information in a wireless communication channel comprising.” See, e.g.: **20.1 Introduction**

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
wireless communication channel comprising:	Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission (as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes.

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.
[10.2] receiving a first digital signal comprising first data to be transmitted;	802.11n D2.0 discloses "receiving a first digital signal comprising first data to be transmitted." See, e.g.: **high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19 **non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

Claim 10 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**

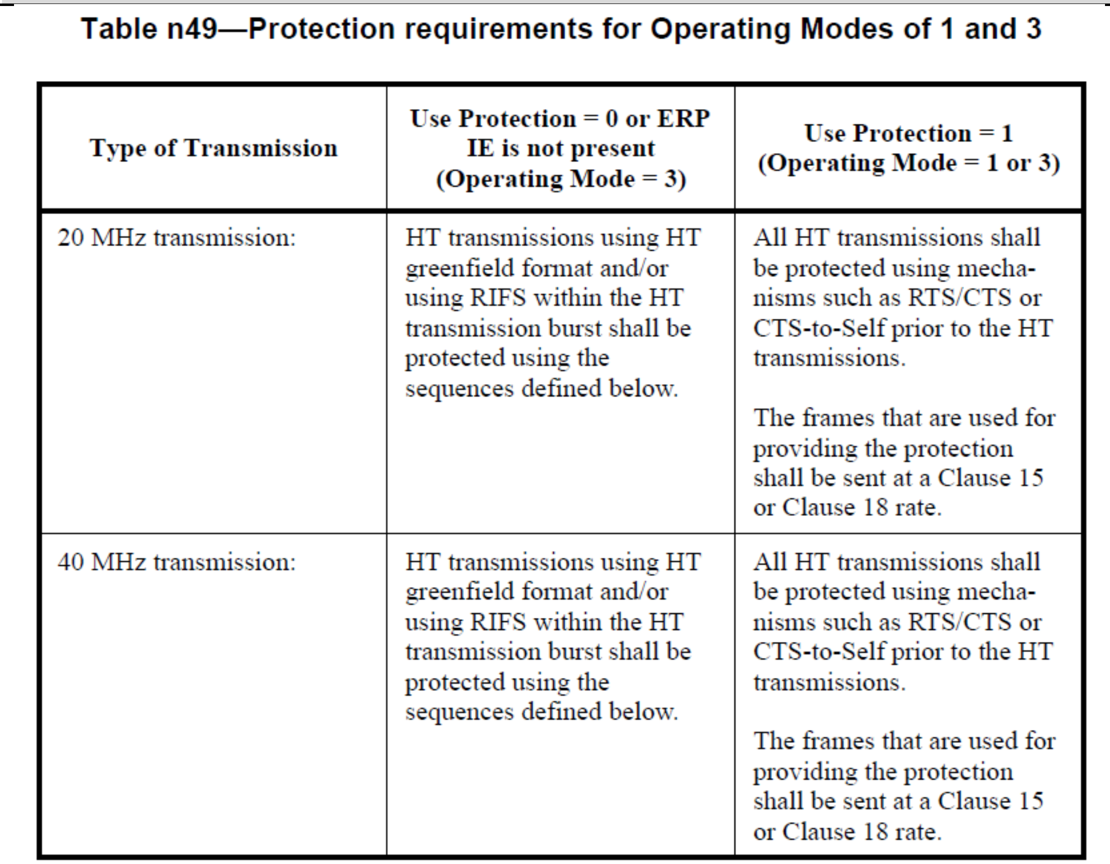
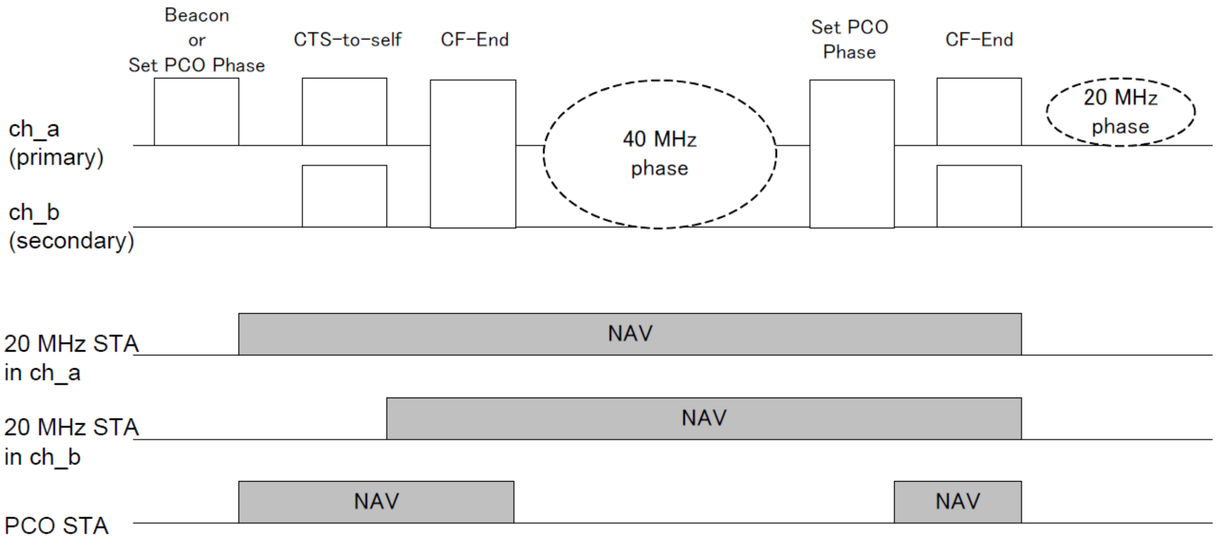


Table n49—Protection requirements for Operating Modes of 1 and 3

Type of Transmission	**Use Protection = 0 or ERP IE is not present (Operating Mode = 3)**	**Use Protection = 1 (Operating Mode = 1 or 3)**
20 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.
40 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.
NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

Claim 10 of the '802 Patent	**Prior Art Reference – 802.11n D2.0**
	 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

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	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

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	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

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	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $$r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t \right) \right\} \quad (20\text{-}1)$$ where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

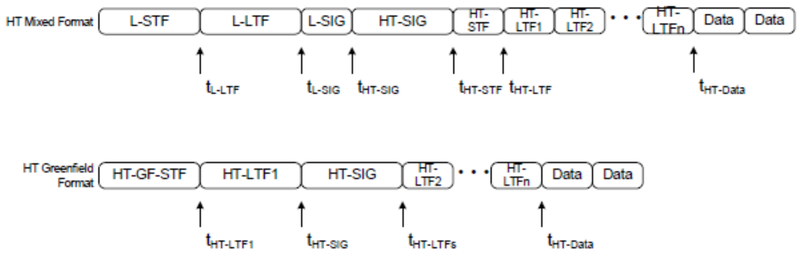

Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = \; & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right) T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}\left(t - t_{HT-DATA}\right) \end{aligned} \qquad (20\text{-}2)$$

where

$$t_{L-LTF} = T_{L-STF}$$

$$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$$

$$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$$

$$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1}) \\ & + r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2) T_{HT-LTFs}) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \quad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\text{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\text{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j 2 \pi k \Delta_F t) \quad (20\text{-}4)$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \quad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \quad (20\text{-}6)$$

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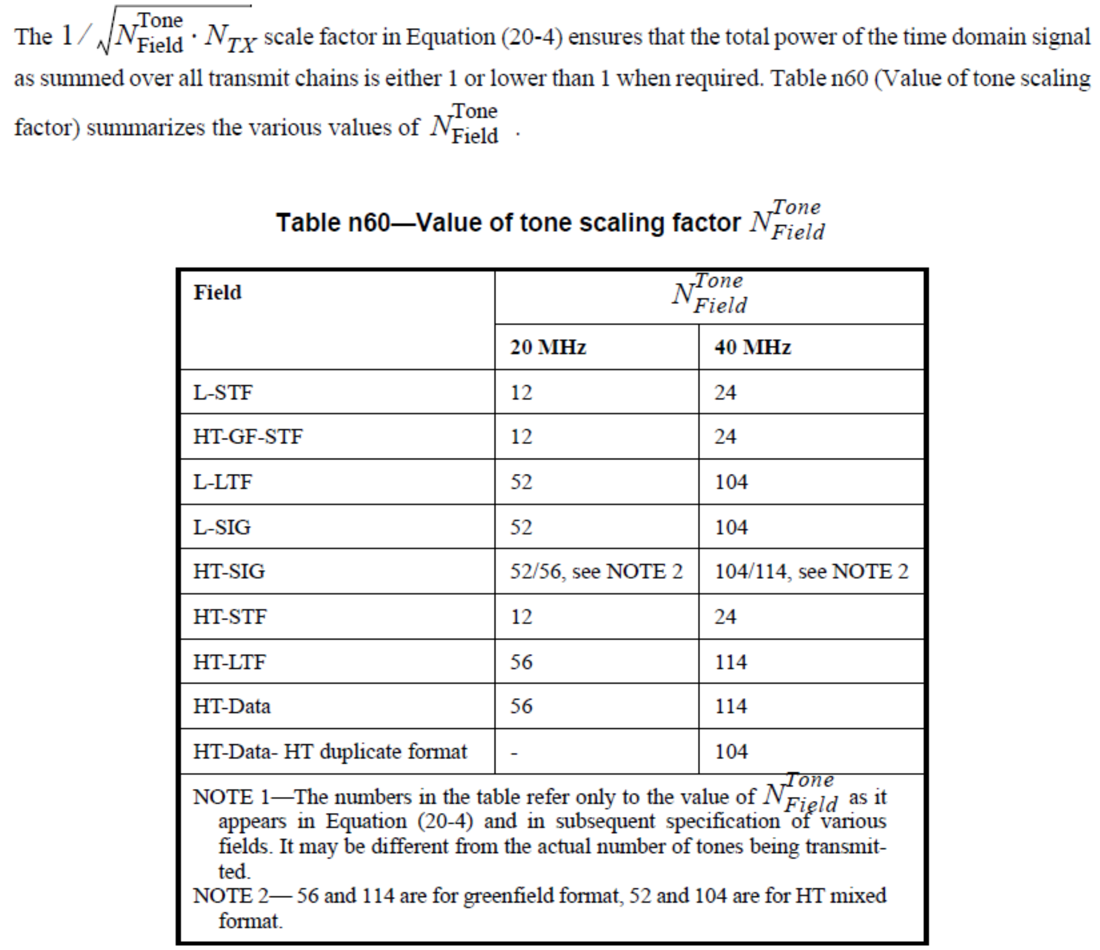

The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	40 MHz
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

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	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS} \cdot N^{Tone}_{HT-DATA}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P^k_{(i_{STS}, n)}) \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T^{i_{STS}}_{CS}))$ (20-58) where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

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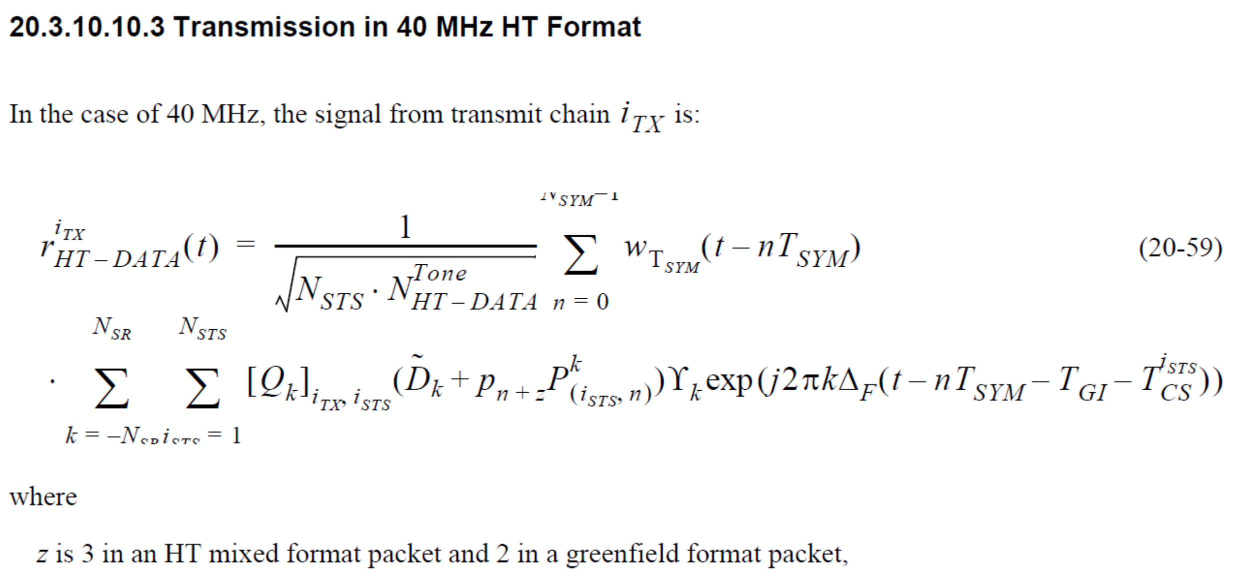
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS}\cdot N^{Tone}_{HT-DATA}}}\sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}}\sum_{i_{STS}=1}^{N_{STS}}[Q_k]_{i_{TX},i_{STS}}(\tilde{D}_k + p_{n+z}P^k_{(i_{STS},n)})\Upsilon_k \exp(j2\pi k\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{STS}}_{CS}))$ (20-59) where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

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	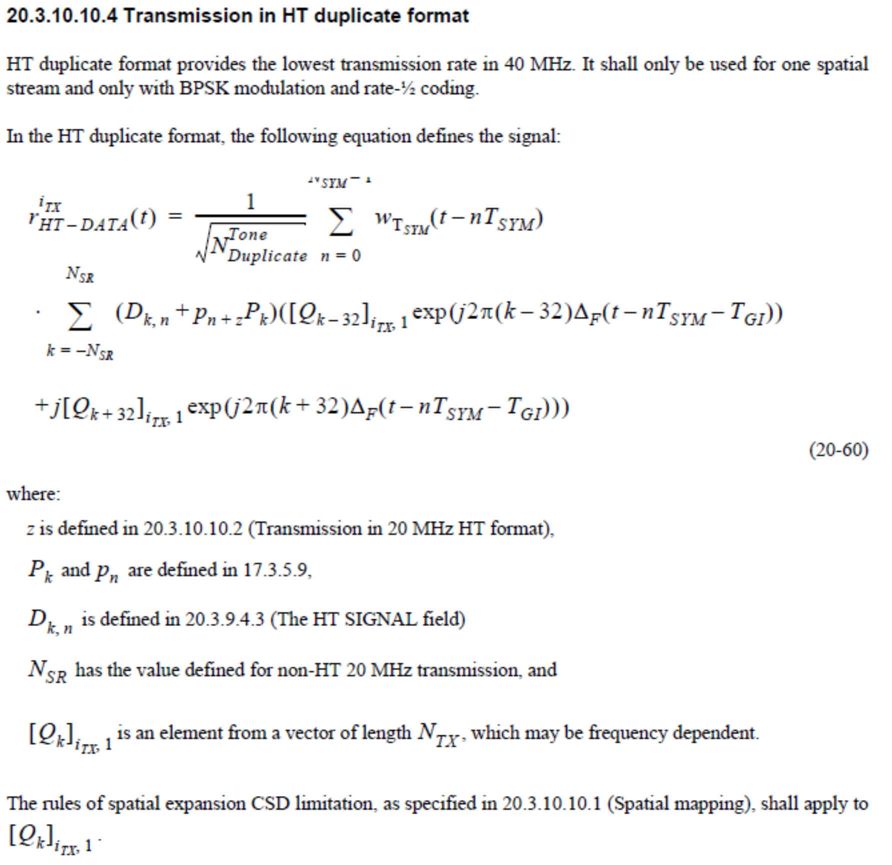 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n}+p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI})) + j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

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	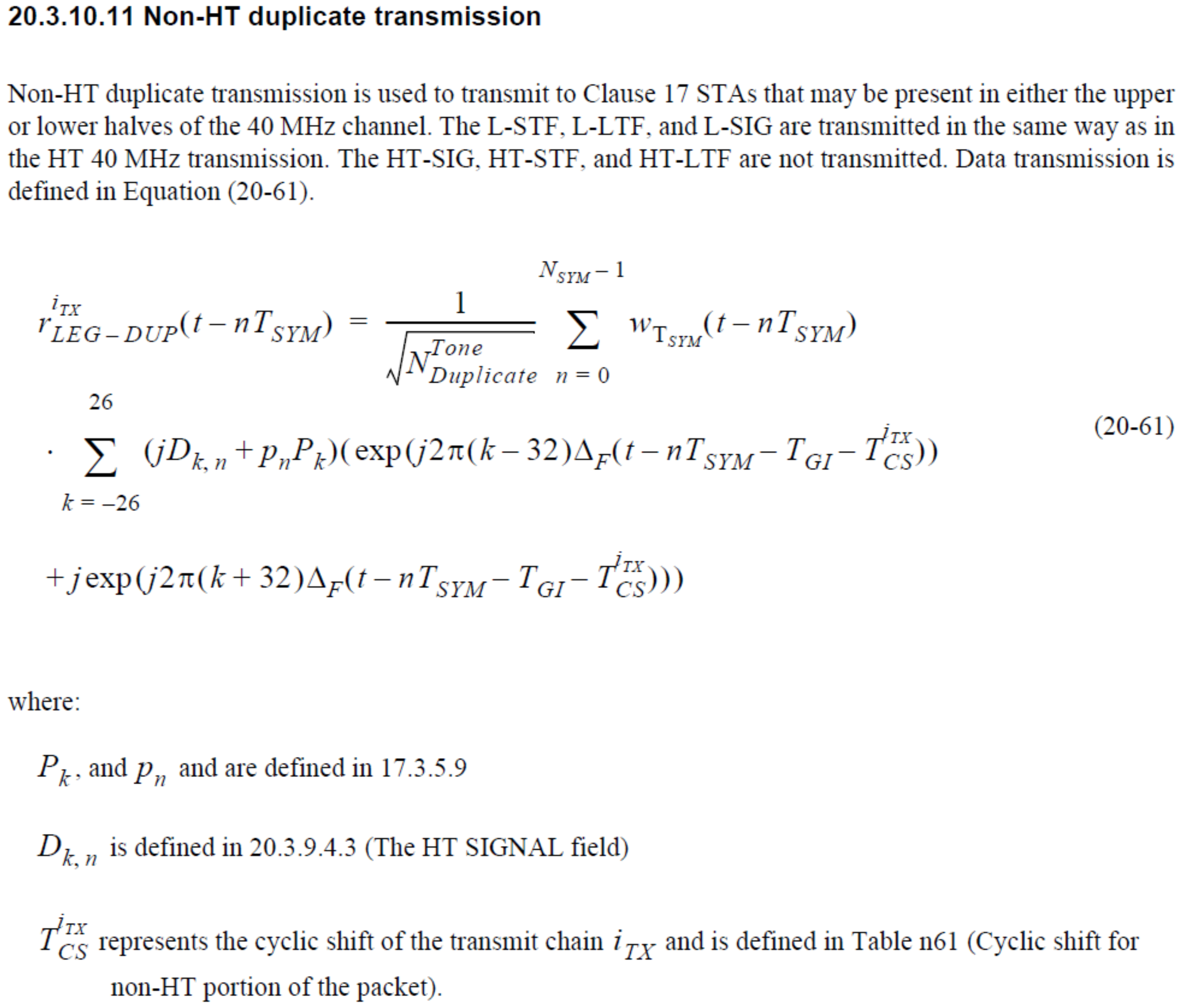 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r^{i_{TX}}_{LEG-DUP}(t-nT_{SYM}) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n}+p_nP_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T^{i_{TX}}_{CS}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

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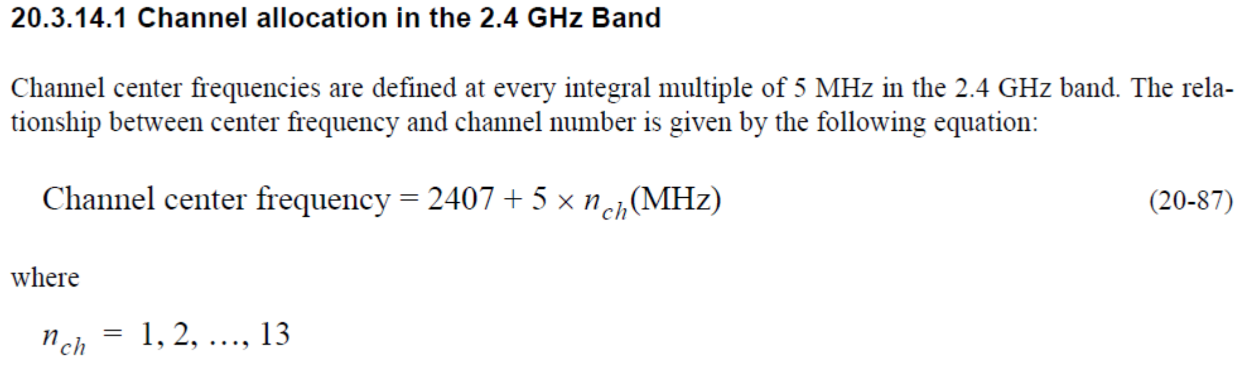
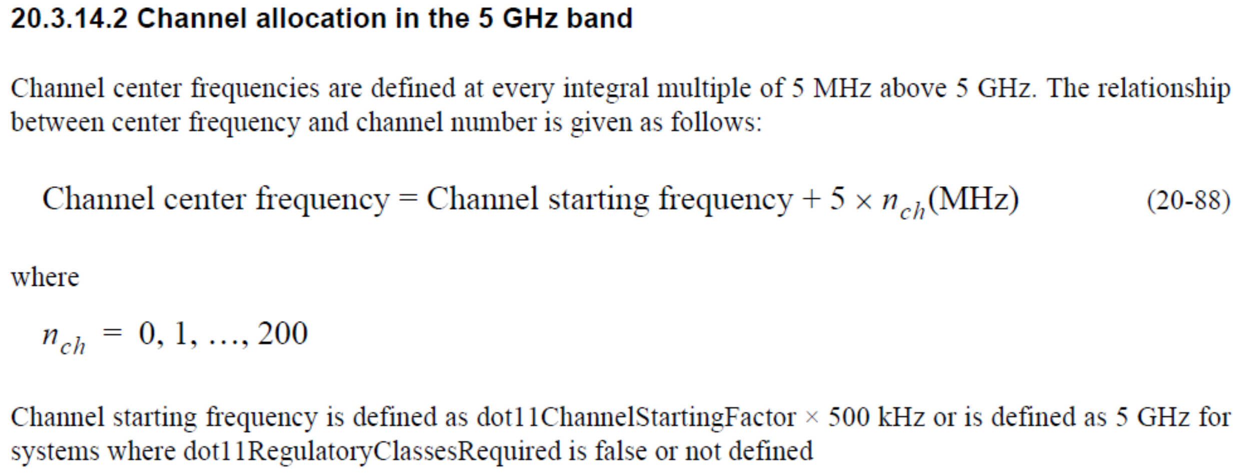
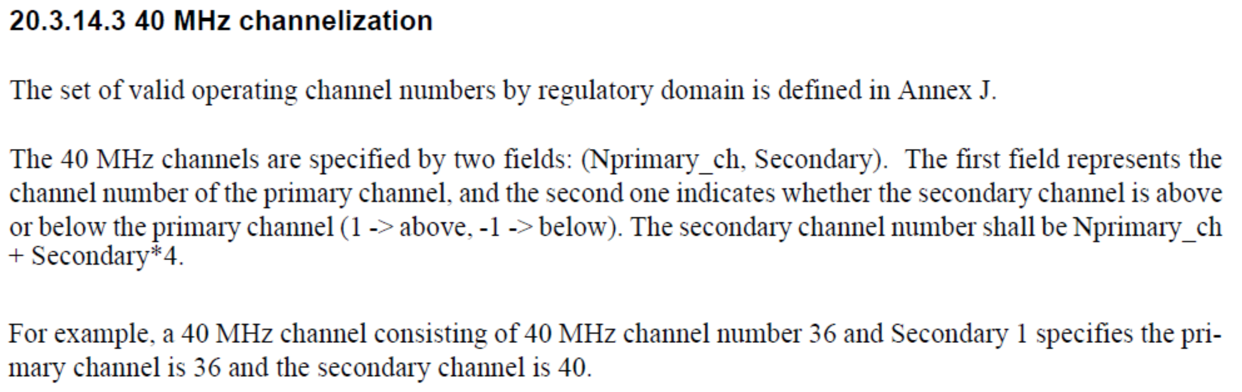
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz}) \quad (20\text{-}87)$ where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz}) \quad (20\text{-}88)$ where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

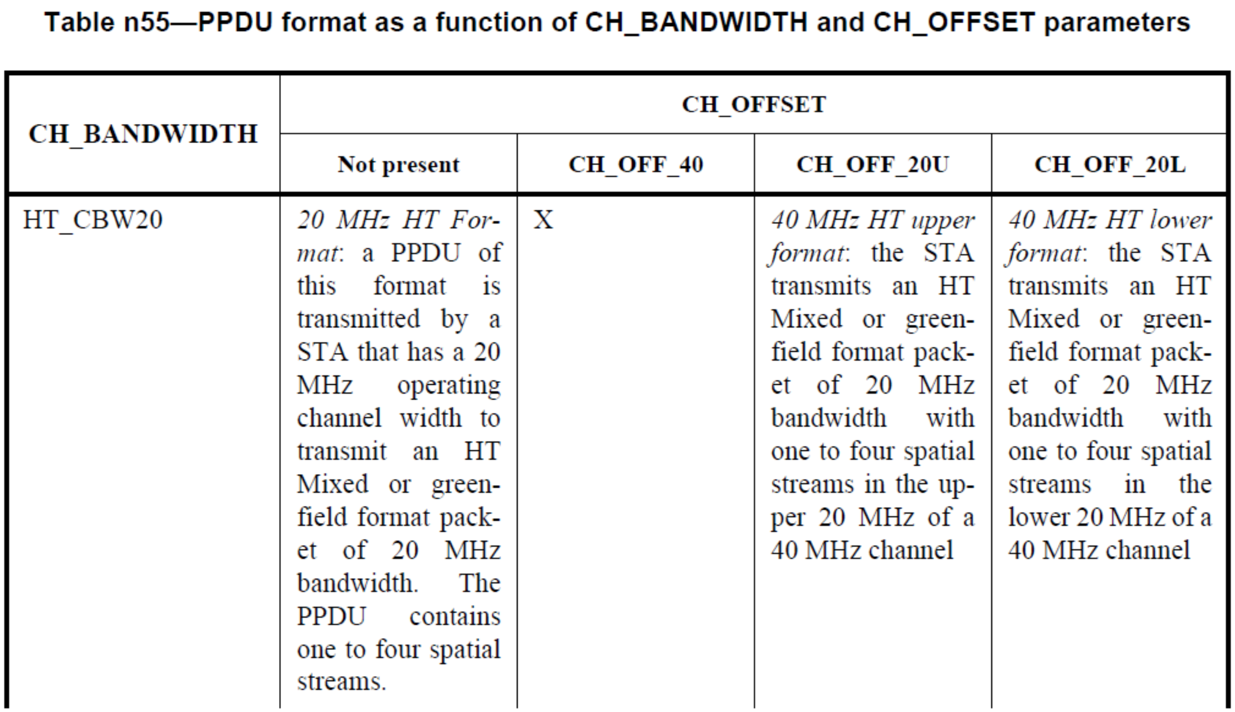
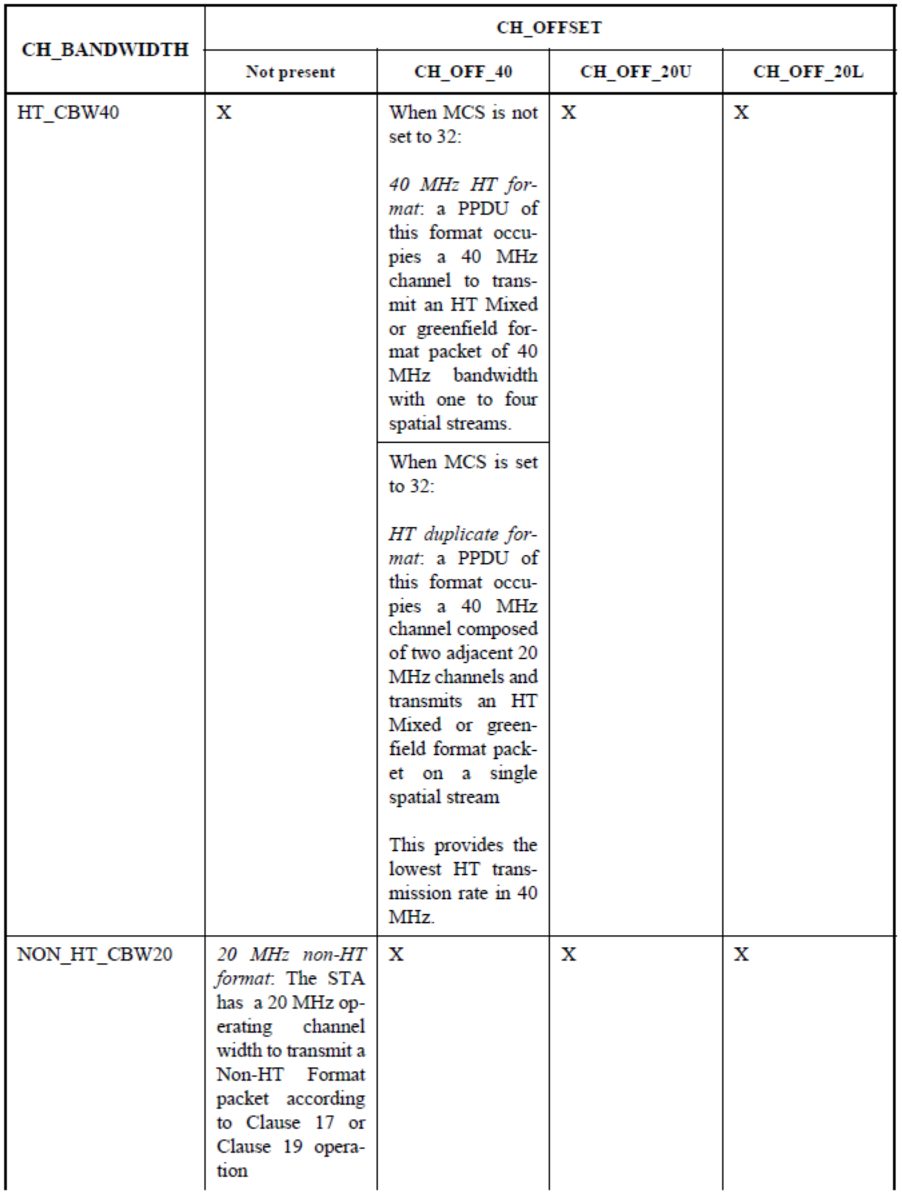
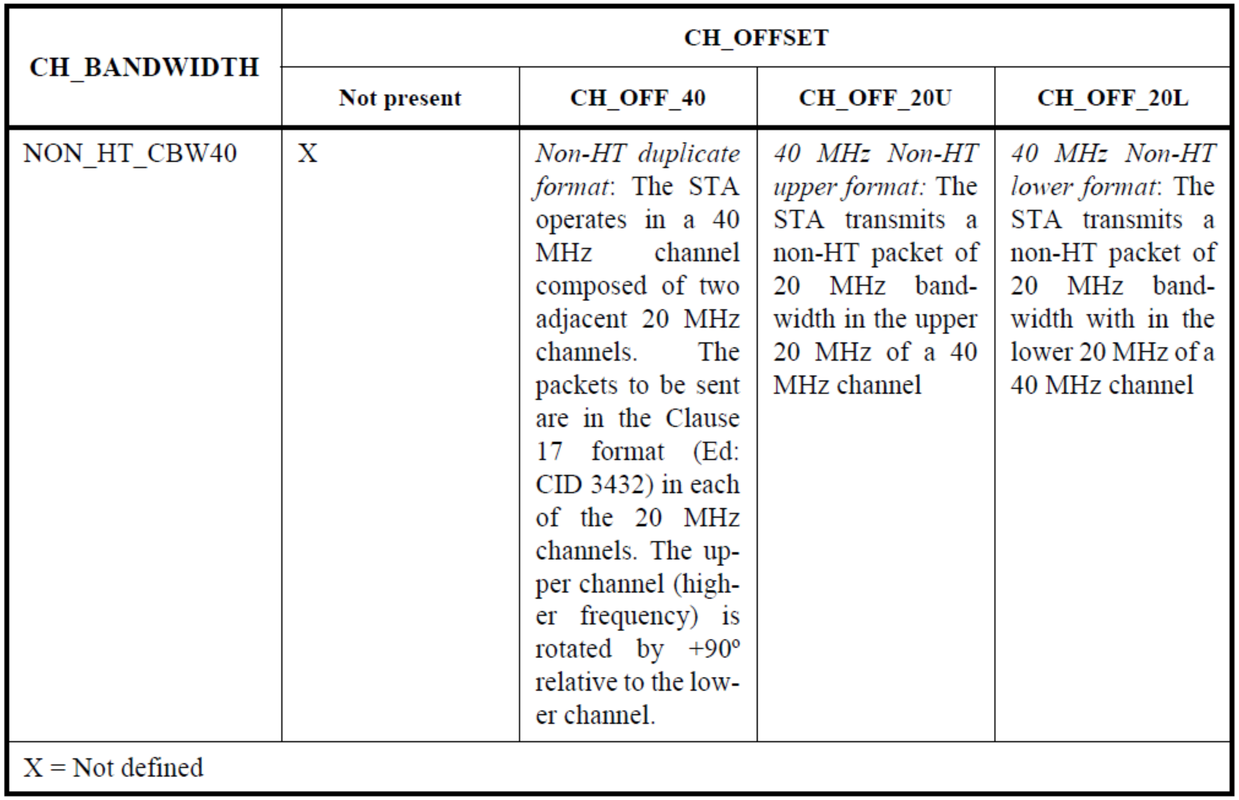
Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.20.3 

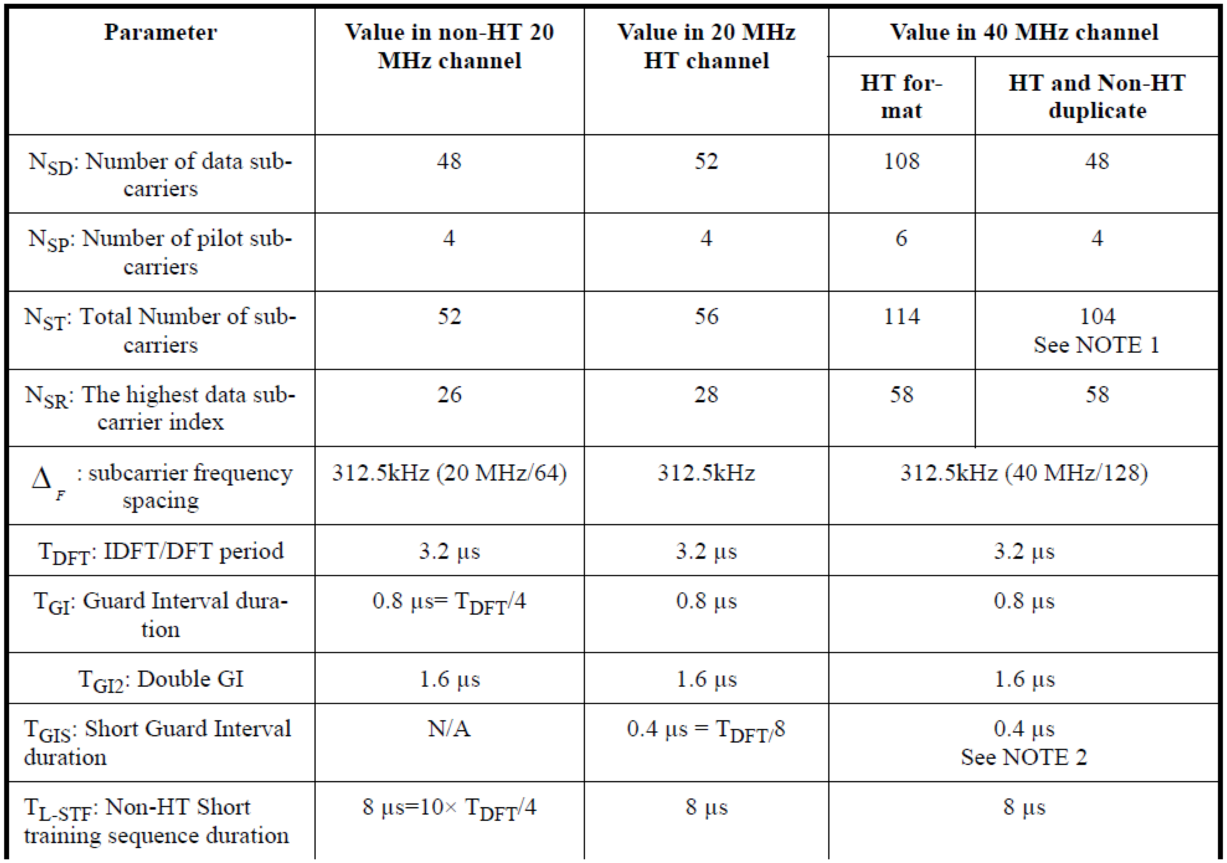
Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel



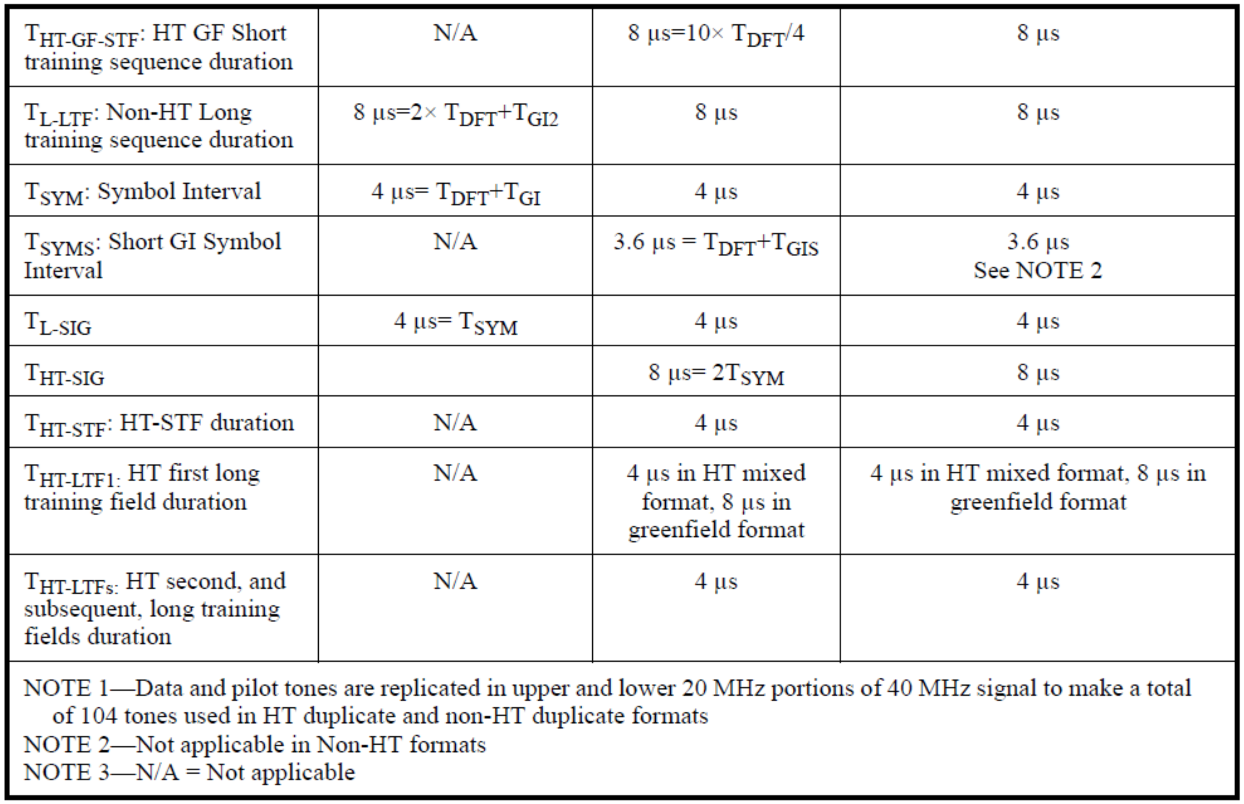
CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

<table>
<tr><th>Claim 10 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>NON_HT_CBW40</td><td>X</td><td><i>Non-HT duplicate format</i>: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.</td><td><i>40 MHz Non-HT upper format:</i> The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel</td><td><i>40 MHz Non-HT lower format</i>: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel</td></tr>
<tr><td colspan="5">X = Not defined</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n55
</td></tr>
</table>

Claim 10 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	Table n58—Timing related constants 

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

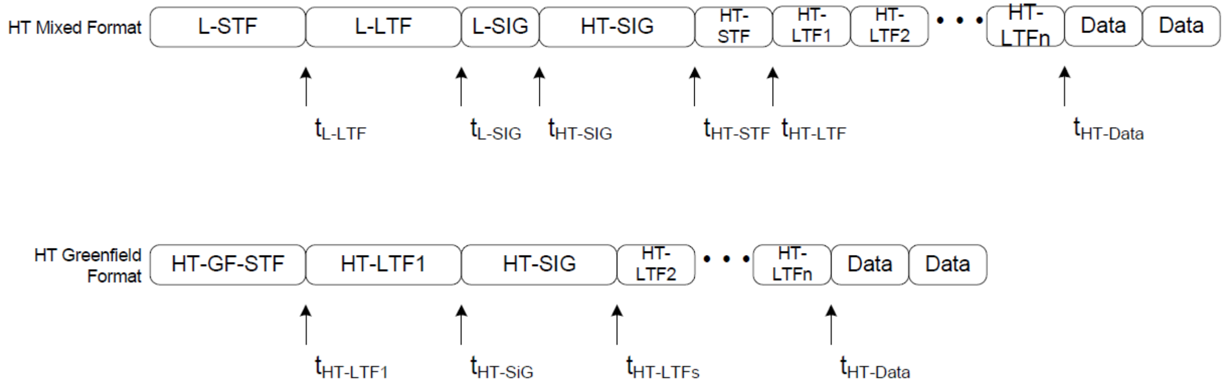
Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0



$T_{HT\text{-}GF\text{-}STF}$: HT GF Short training sequence duration	N/A	8 µs=10× T_{DFT}/4	8 µs
$T_{L\text{-}LTF}$: Non-HT Long training sequence duration	8 µs=2× $T_{DFT}+T_{GI2}$	8 µs	8 µs
T_{SYM}: Symbol Interval	4 µs= $T_{DFT}+T_{GI}$	4 µs	4 µs
T_{SYMS}: Short GI Symbol Interval	N/A	3.6 µs = $T_{DFT}+T_{GIS}$	3.6 µs See NOTE 2
$T_{L\text{-}SIG}$	4 µs= T_{SYM}	4 µs	4 µs
$T_{HT\text{-}SIG}$		8 µs= 2T_{SYM}	8 µs
$T_{HT\text{-}STF}$: HT-STF duration	N/A	4 µs	4 µs
$T_{HT\text{-}LTF1}$: HT first long training field duration	N/A	4 µs in HT mixed format, 8 µs in greenfield format	4 µs in HT mixed format, 8 µs in greenfield format
$T_{HT\text{-}LTFs}$: HT second, and subsequent, long training fields duration	N/A	4 µs	4 µs

NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable

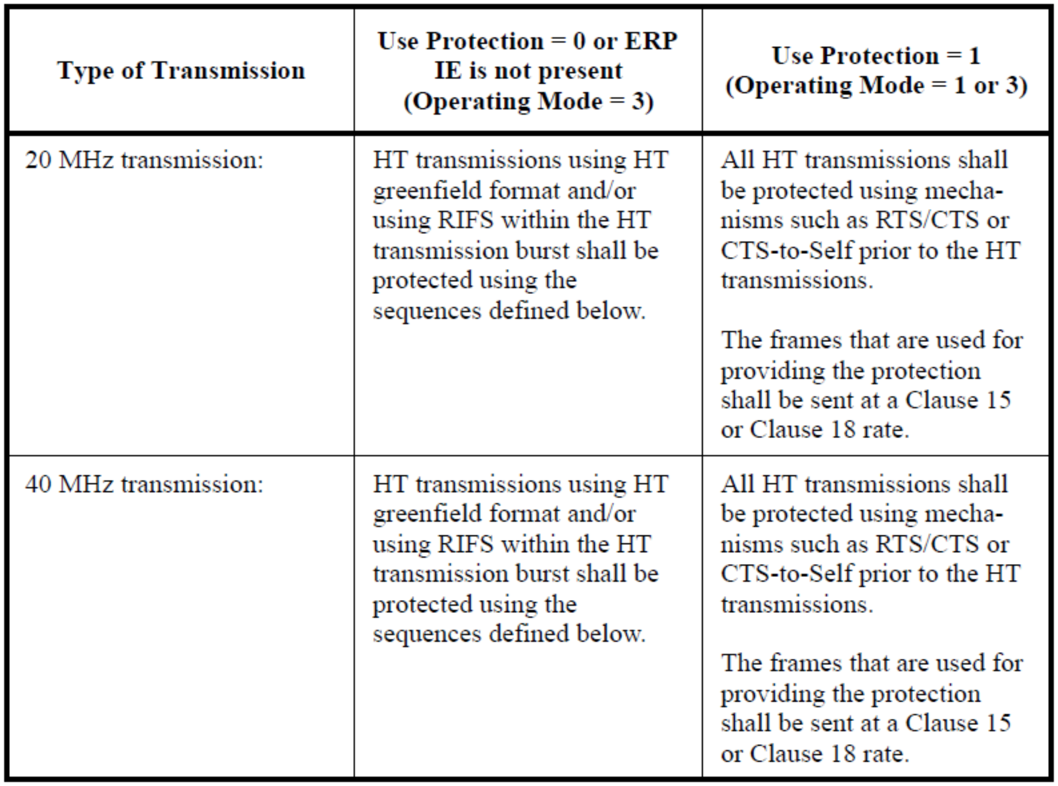
See, e.g., 802.11n D2.0 Table n58

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.
[10.3] receiving a second digital signal comprising second data to be transmitted;	802.11n D2.0 discloses “receiving a second digital signal comprising second data to be transmitted.” See, e.g.: **high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19 **non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission.

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0

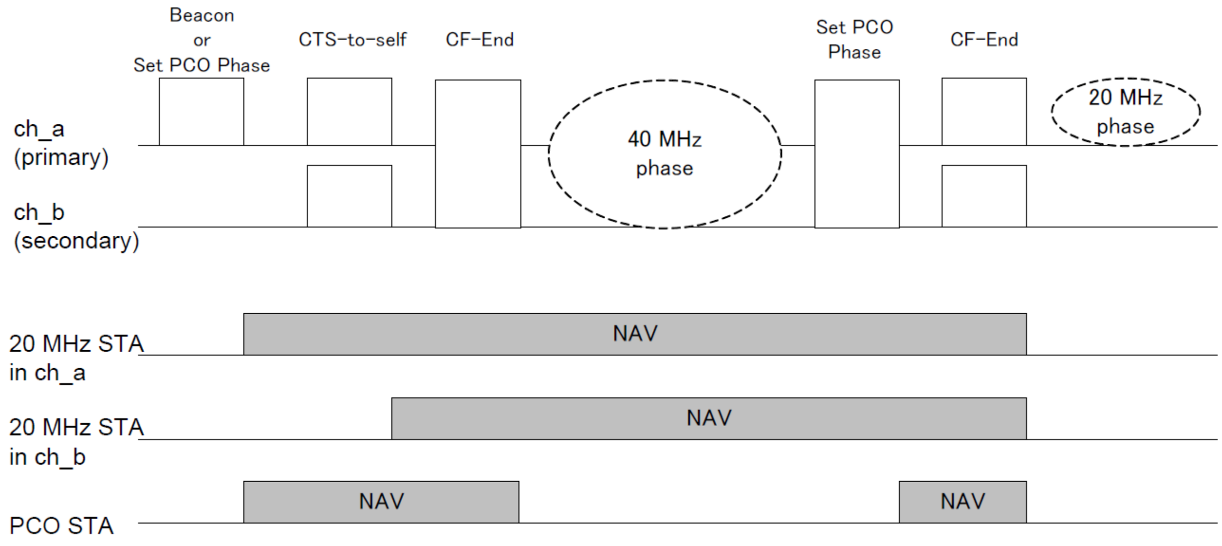
Table n49—Protection requirements for Operating Modes of 1 and 3



Type of Transmission	Use Protection = 0 or ERP IE is not present (Operating Mode = 3)	Use Protection = 1 (Operating Mode = 1 or 3)
20 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.
40 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.
NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

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	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $$r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t\right)\right\} \quad (20\text{-}1)$$ where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

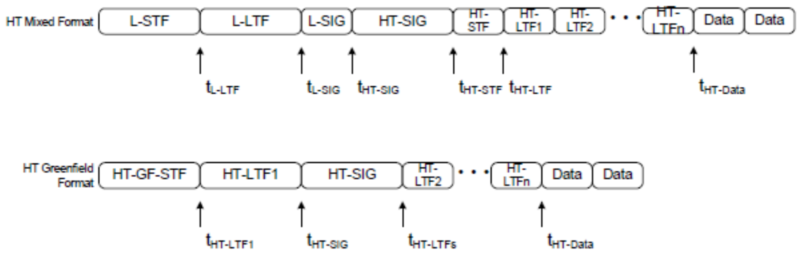

Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = \; & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right)T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}\left(t - t_{HT-DATA}\right) \end{aligned} \qquad (20\text{-}2)$$

where

$$t_{L-LTF} = T_{L-STF}$$

$$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$$

$$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$$

$$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1}) \\ & + r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2)T_{HT-LTFs}) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \qquad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\text{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\text{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j 2\pi k \Delta_F t) \qquad (20\text{-}4)$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \qquad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \qquad (20\text{-}6)$$

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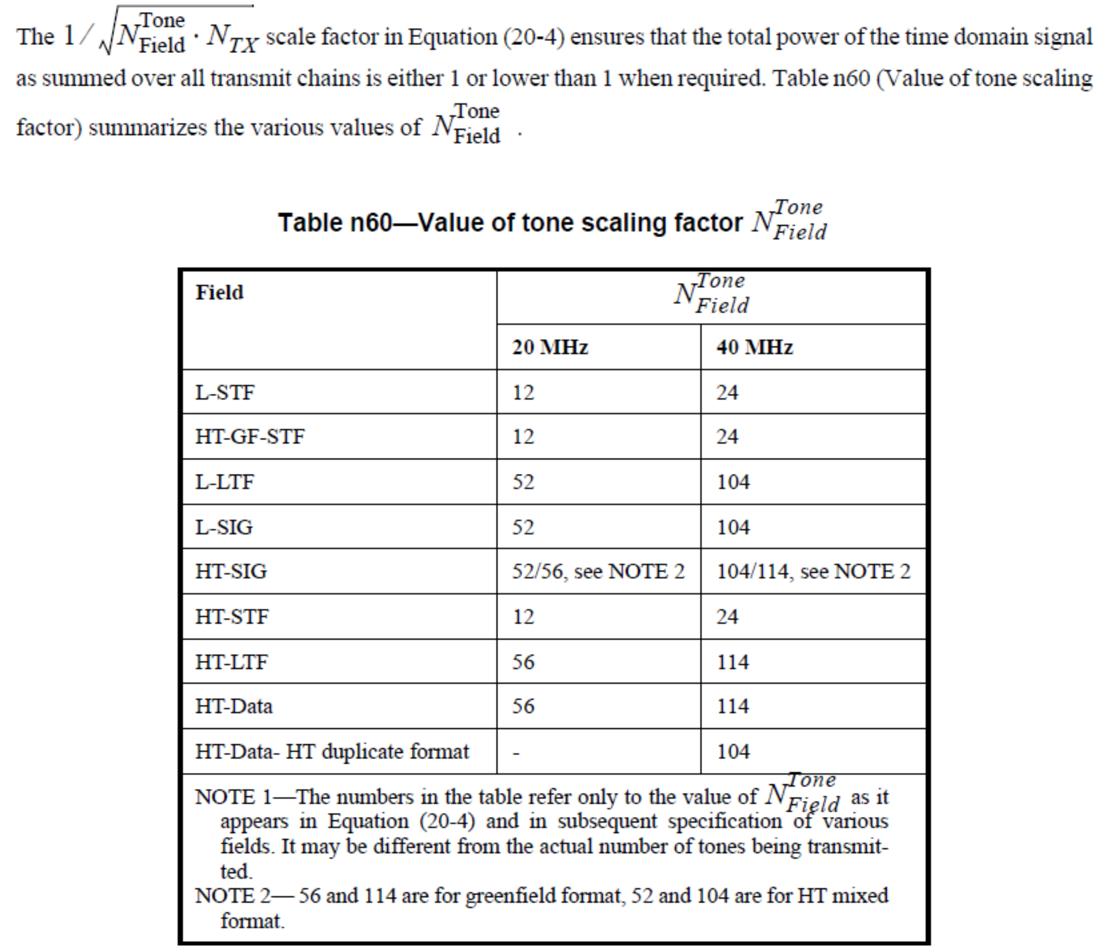

The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	40 MHz
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

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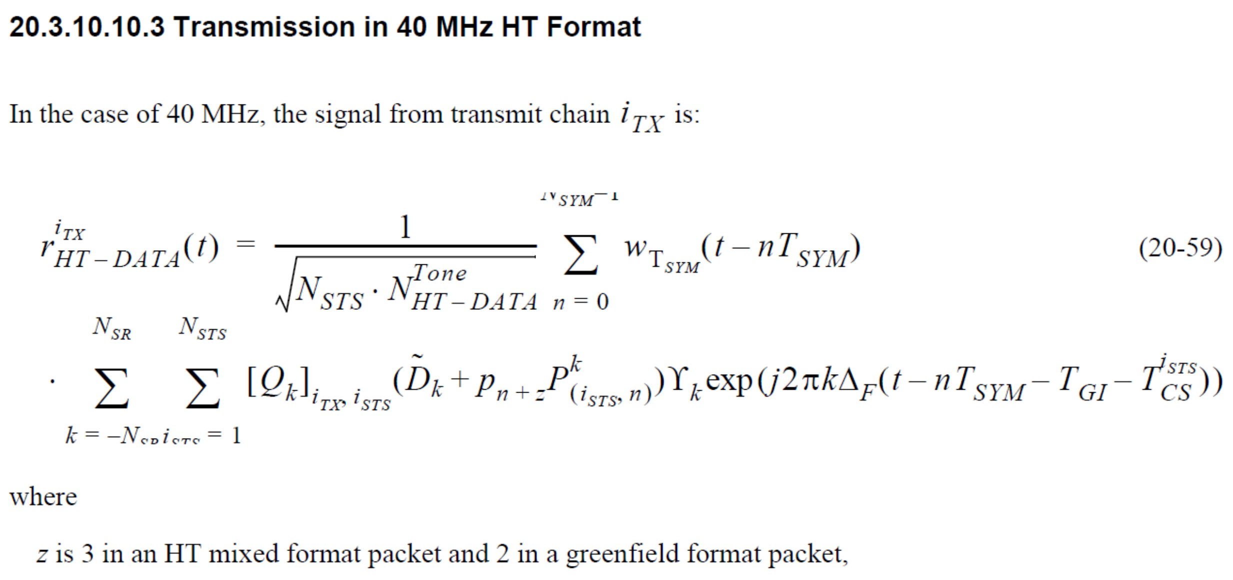
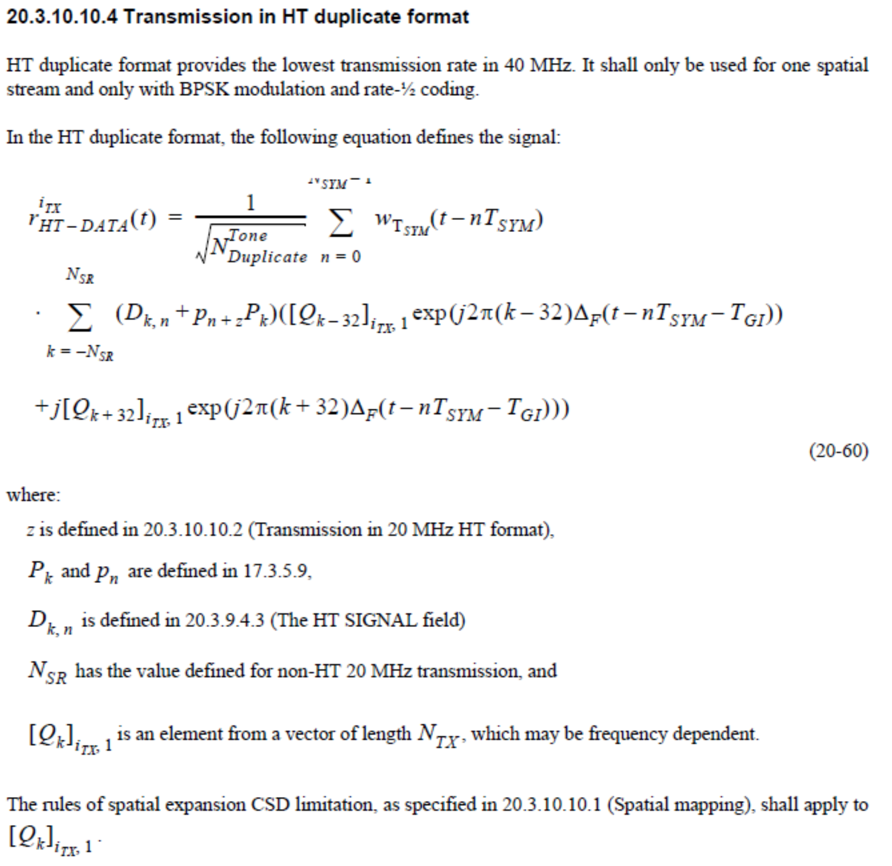
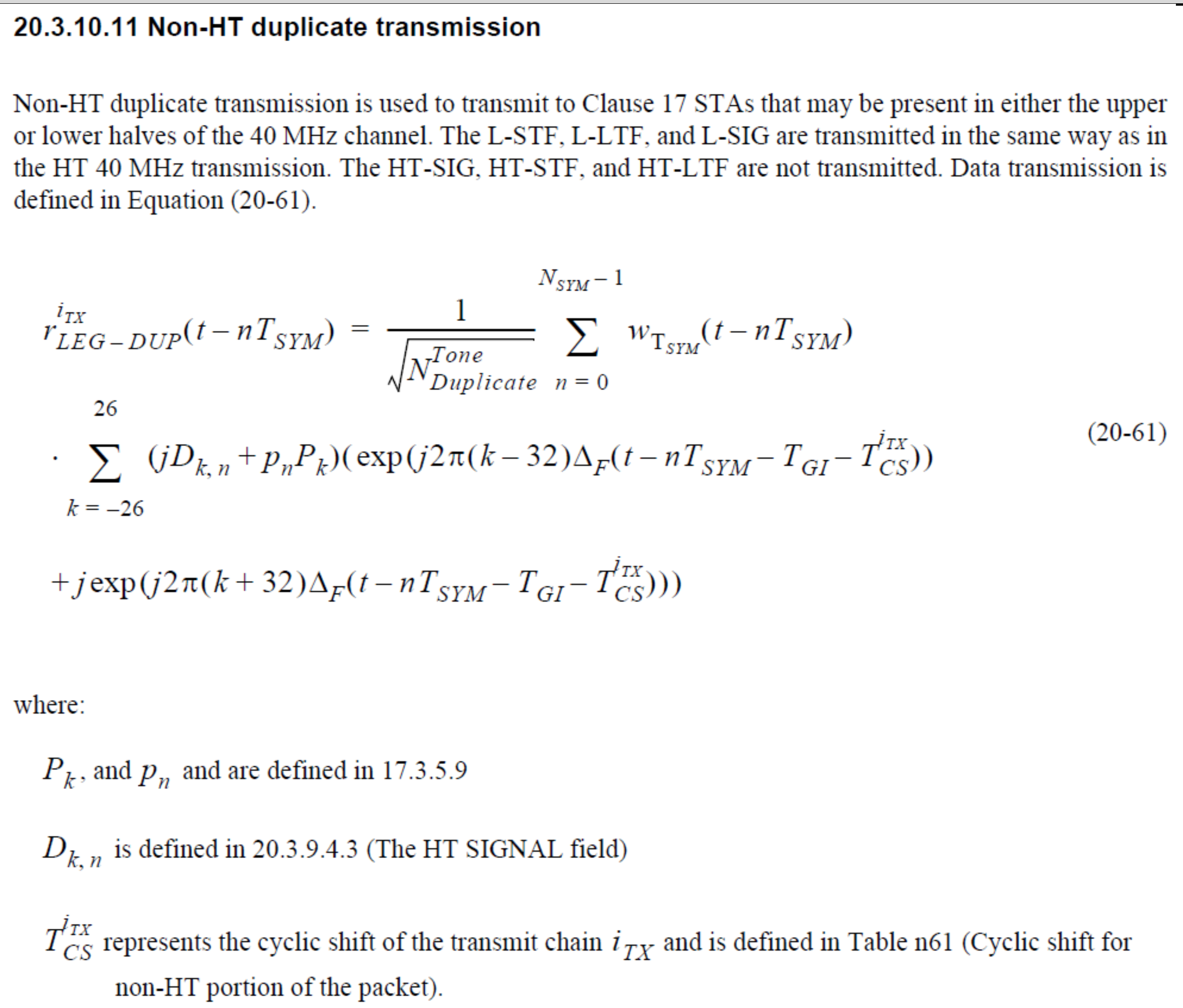
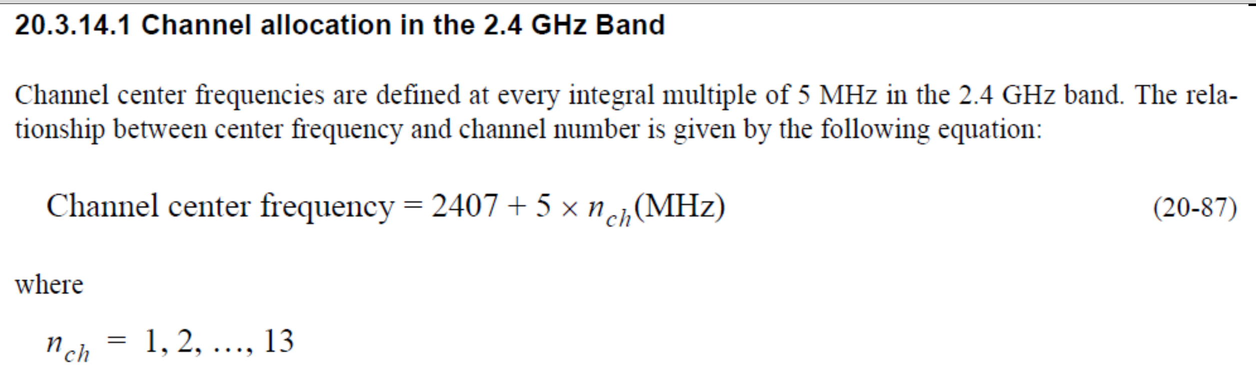
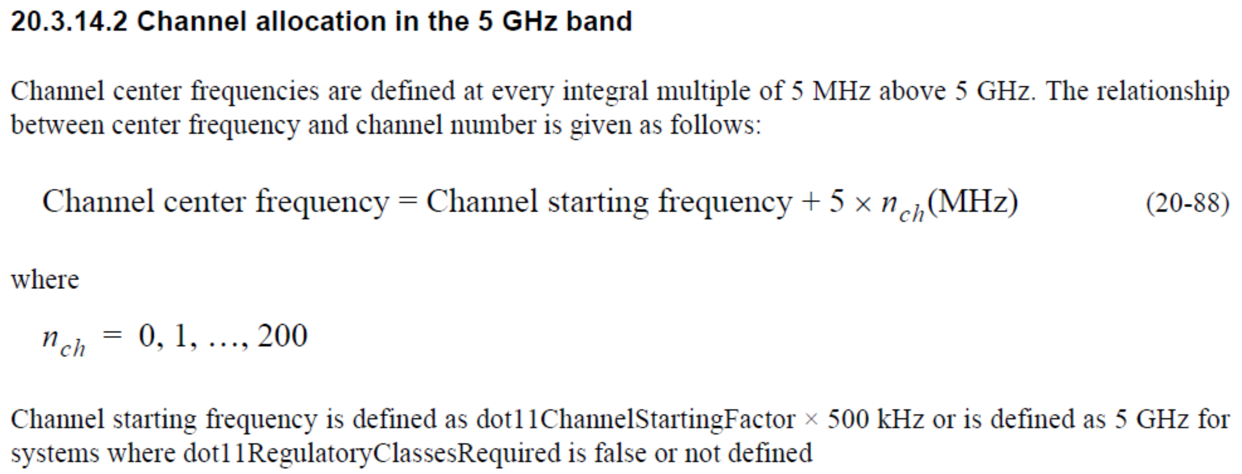
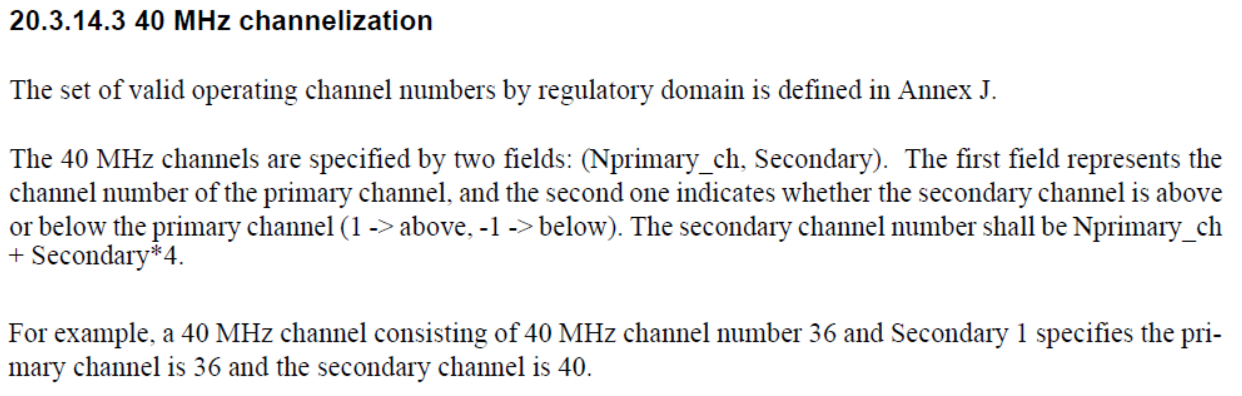
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P_{(i_{STS},n)}^{k}) \exp(j 2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (20-58) where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

Claim 10 of the '802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P_{(i_{STS}, n)}^k) \Upsilon_k \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (20-59) where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n}+p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI})) + j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $$r_{LEG-DUP}^{i_{TX}}(t-nT_{SYM}) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n}+p_nP_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{TX}})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{TX}}))) \quad (20\text{-}61)$$ where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T_{CS}^{i_{TX}}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 10 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz})$ (20-87) where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz})$ (20-88) where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

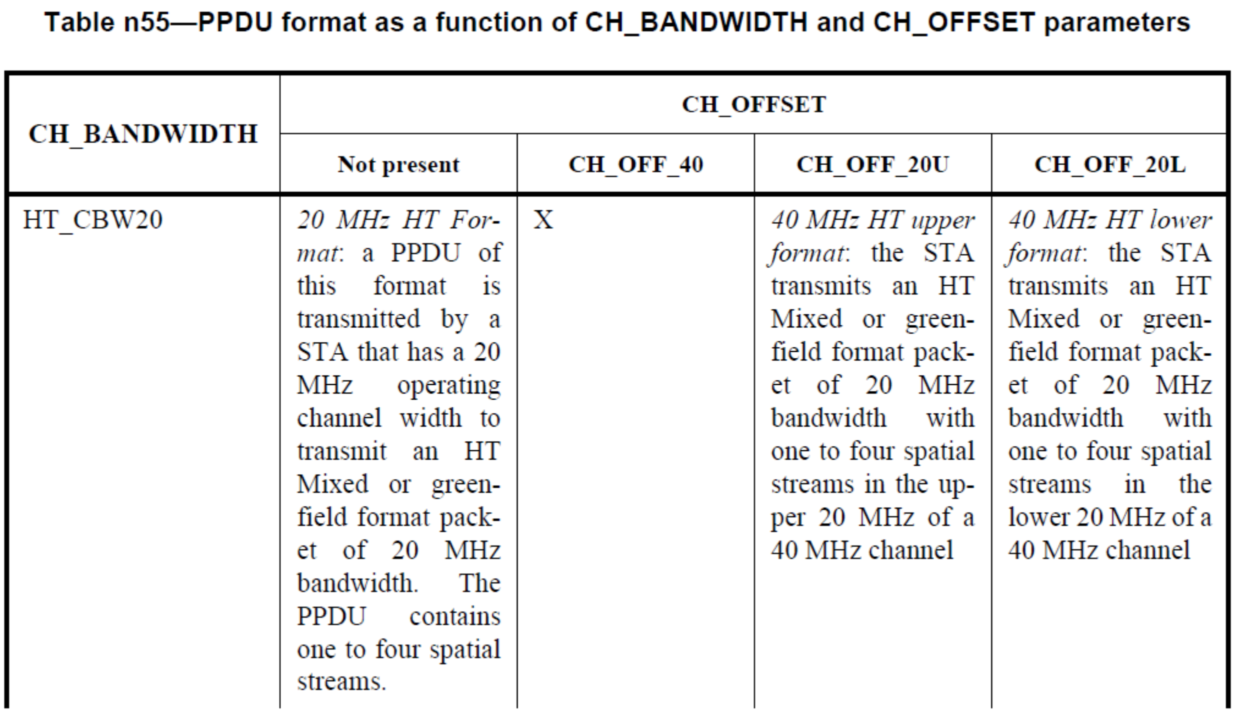
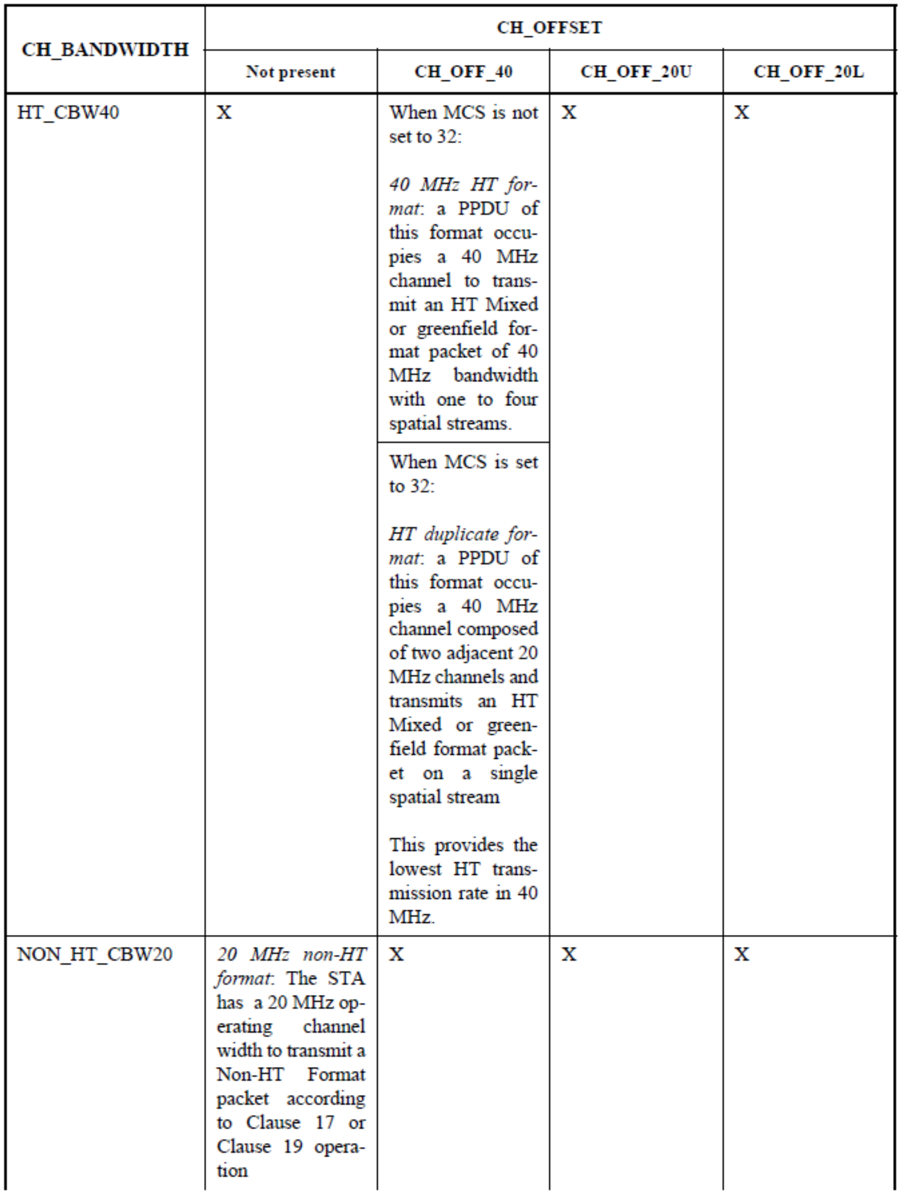
Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.20.3 

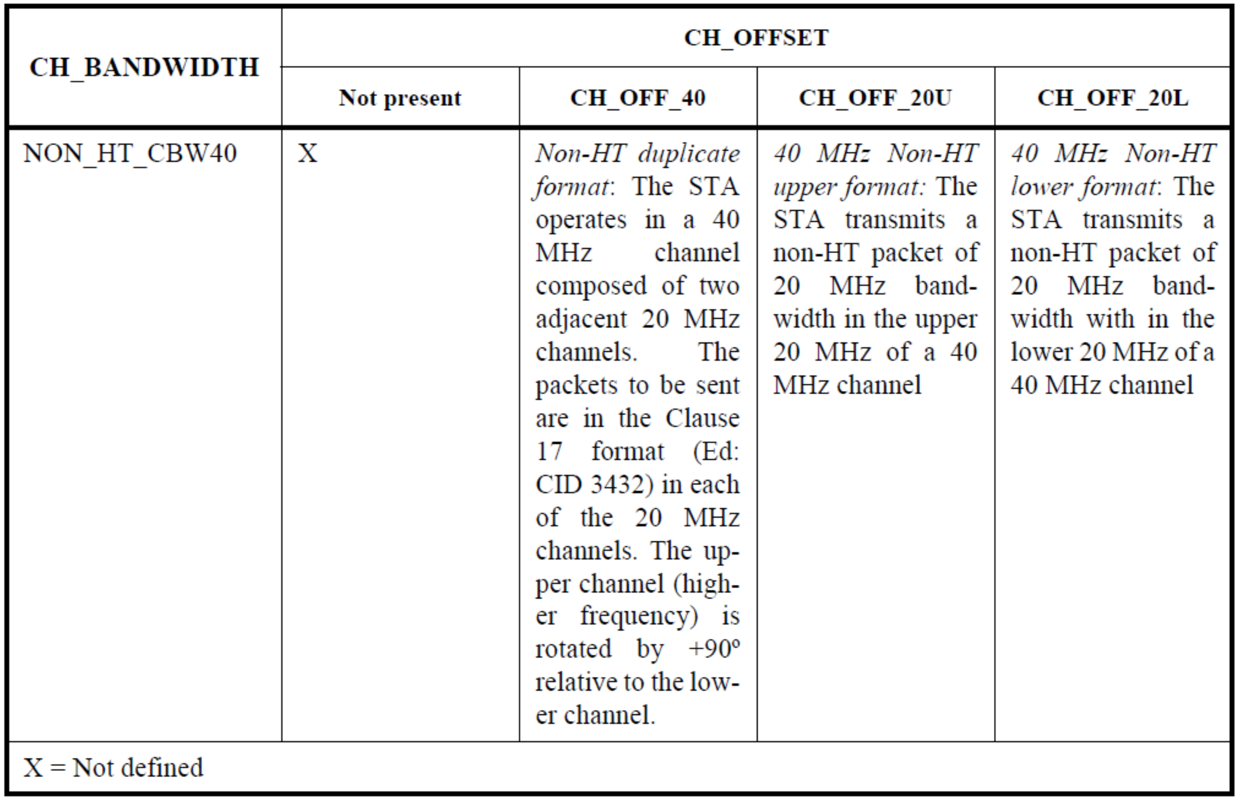
Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel



CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0



CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
NON_HT_CBW40	X	*Non-HT duplicate format*: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.	*40 MHz Non-HT upper format:* The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel	*40 MHz Non-HT lower format*: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel
X = Not defined				

See, e.g., 802.11n D2.0 Table n55

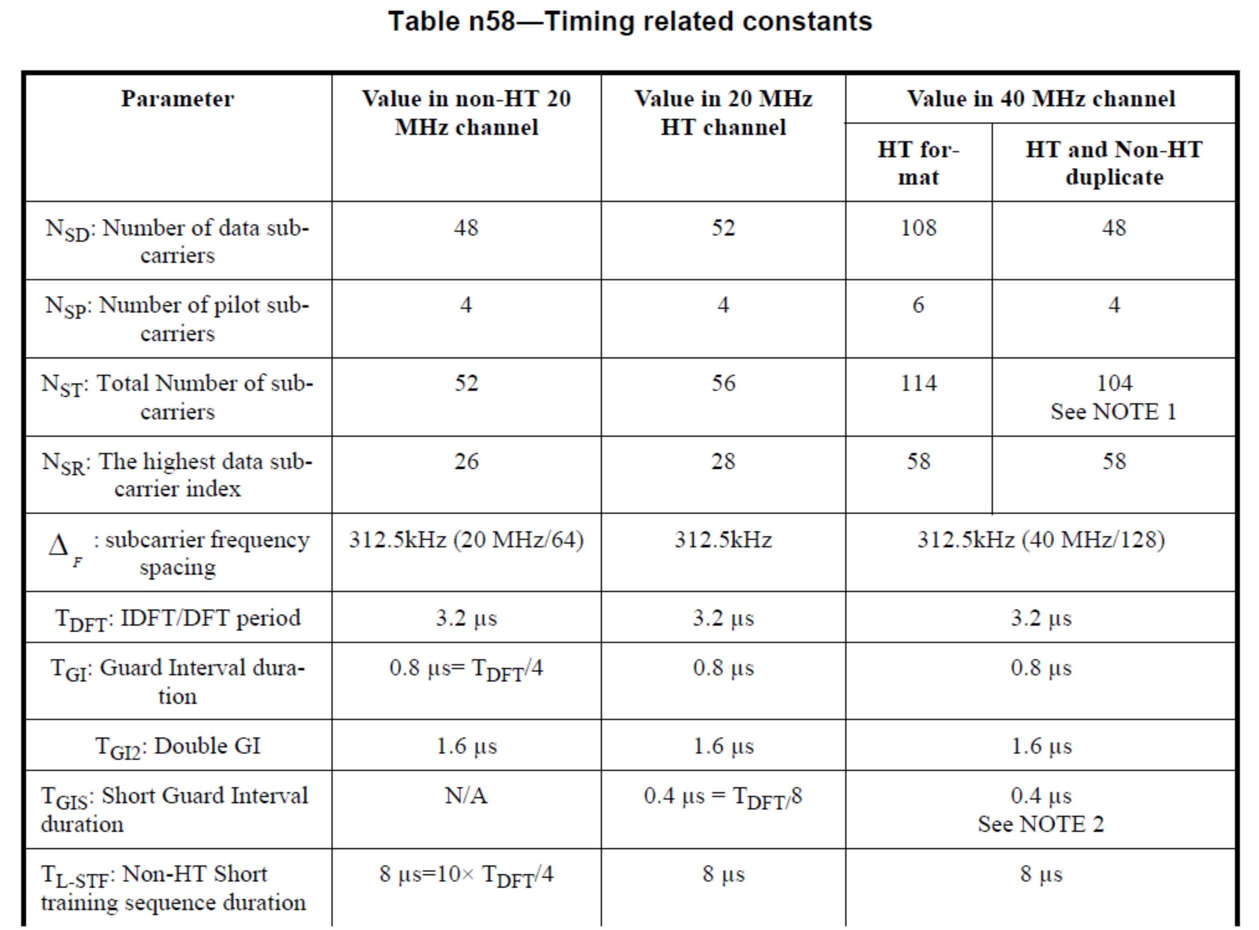
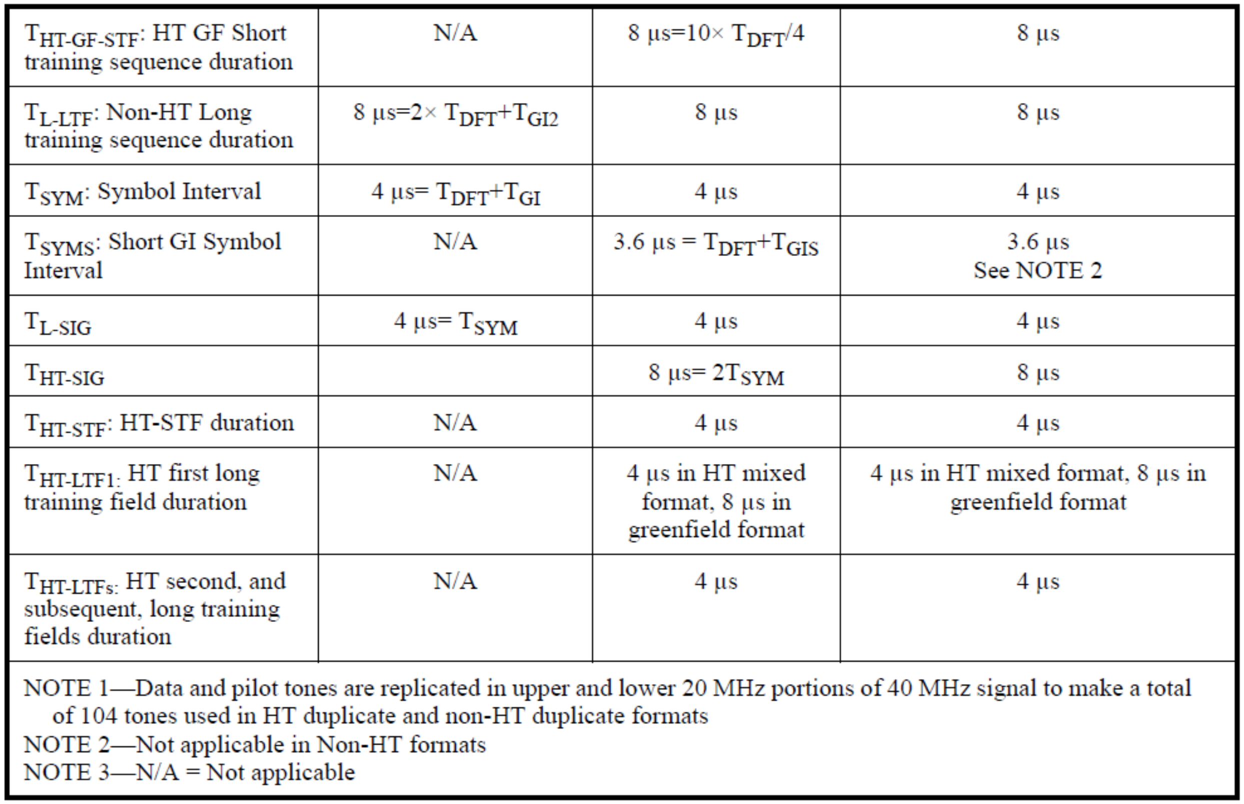
Claim 10 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	

Table n58—Timing related constants

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0



$T_{\text{HT-GF-STF}}$: HT GF Short training sequence duration	N/A	8 µs=10× T_{DFT}/4	8 µs
$T_{\text{L-LTF}}$: Non-HT Long training sequence duration	8 µs=2× T_{DFT}+T_{GI2}	8 µs	8 µs
T_{SYM}: Symbol Interval	4 µs= T_{DFT}+T_{GI}	4 µs	4 µs
T_{SYMS}: Short GI Symbol Interval	N/A	3.6 µs = T_{DFT}+T_{GIS}	3.6 µs See NOTE 2
$T_{\text{L-SIG}}$	4 µs= T_{SYM}	4 µs	4 µs
$T_{\text{HT-SIG}}$		8 µs= 2T_{SYM}	8 µs
$T_{\text{HT-STF}}$: HT-STF duration	N/A	4 µs	4 µs
$T_{\text{HT-LTF1}}$: HT first long training field duration	N/A	4 µs in HT mixed format, 8 µs in greenfield format	4 µs in HT mixed format, 8 µs in greenfield format
$T_{\text{HT-LTFs}}$: HT second, and subsequent, long training fields duration	N/A	4 µs	4 µs

NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable

See, e.g., 802.11n D2.0 Table n58

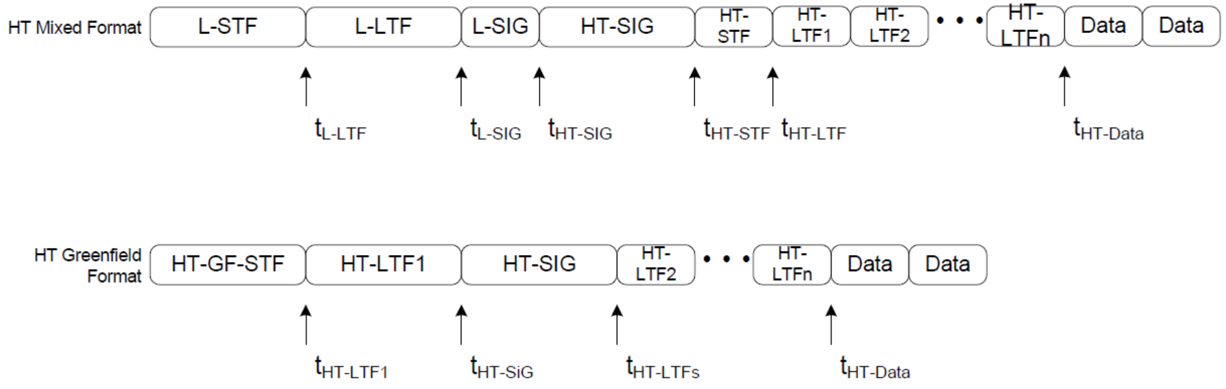
<table>
<tr><th>Claim 10 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>


Figure n65—Timing boundaries for PPDU fields

See, e.g., 802.11n D2.0 Figure n65

Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.
</td></tr>
<tr><td>[10.4] converting the first digital signal into a first analog signal using a first digital-to-analog converter, the first analog signal carrying the first data across a first frequency range;.</td><td>
802.11n D2.0 discloses “converting the first digital signal into a first analog signal using a first digital-to-analog converter, the first analog signal carrying the first data across a first frequency range.” See, e.g.:

high throughput duplicate format (HT duplicate format): A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate.

See, e.g., 802.11n D2.0 § 3.n19
</td></tr>
</table>

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	non-HT duplicate: A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0

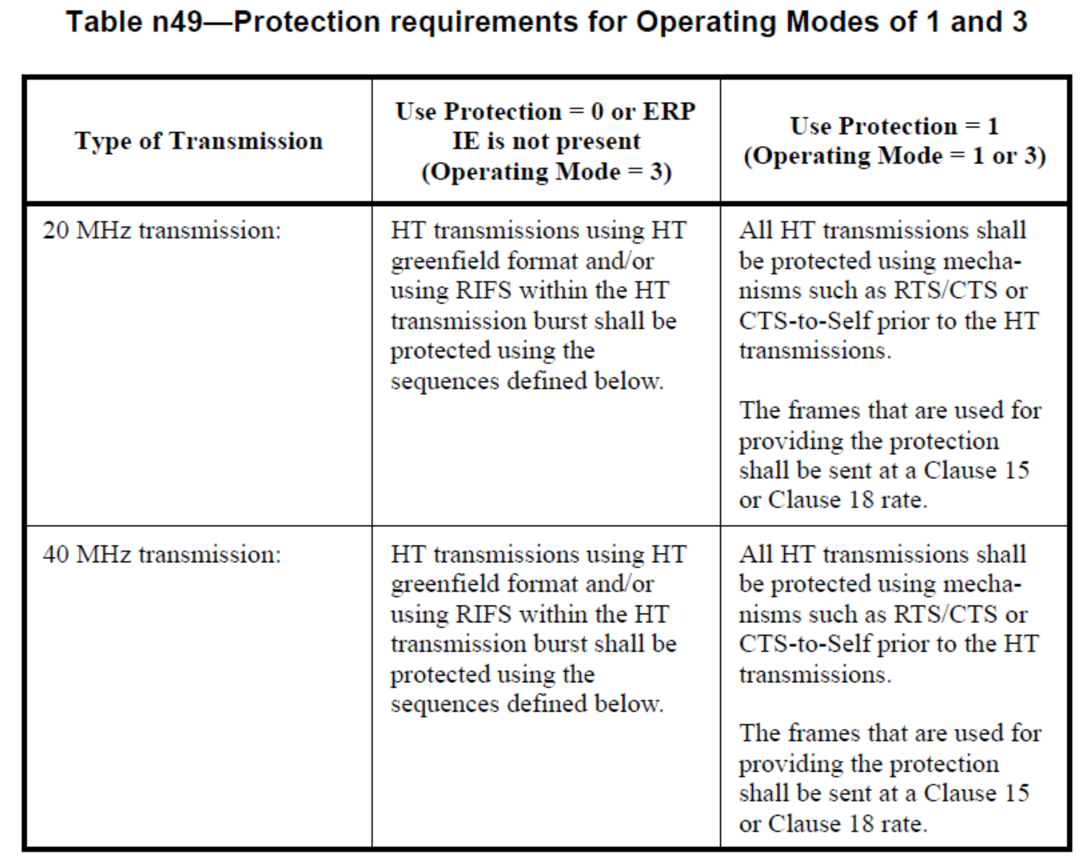
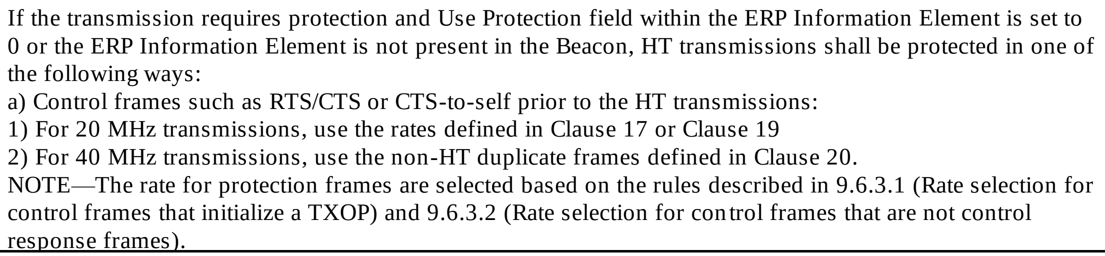


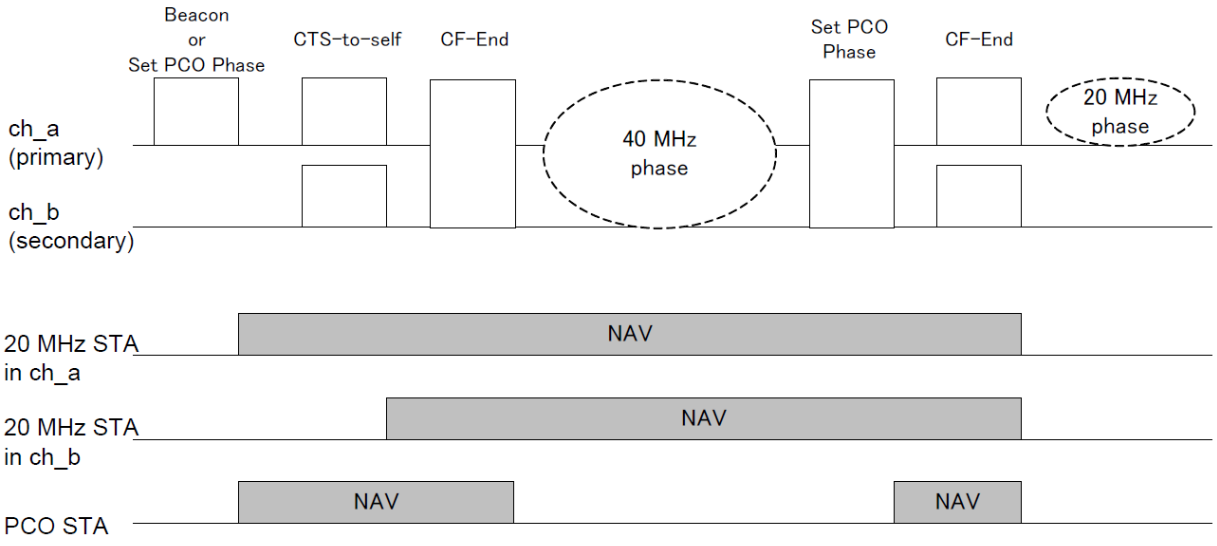
Table n49—Protection requirements for Operating Modes of 1 and 3

Type of Transmission	Use Protection = 0 or ERP IE is not present (Operating Mode = 3)	Use Protection = 1 (Operating Mode = 1 or 3)
20 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.
40 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.



If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.
NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to $N_{SD}-1$ and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t\right)\right\}$ (20-1) where $\mathrm{Re}\left\{ \cdot \right\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

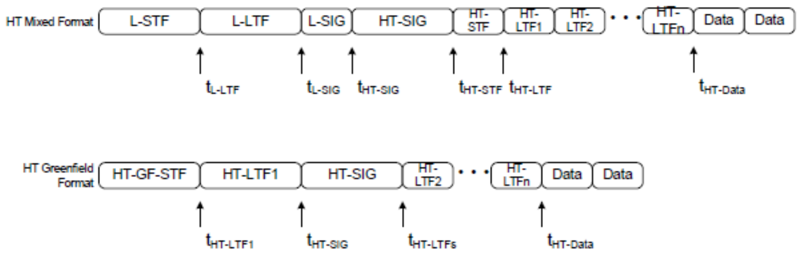


Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right)T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}\left(t - t_{HT-DATA}\right) \end{aligned} \qquad (20\text{-}2)$$

where

$t_{L-LTF} = T_{L-STF}$

$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$

$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$

$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1}) \\ & + r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2)T_{HT-LTFs}) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \quad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\text{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\text{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j 2\pi k \Delta_F t) \quad (20\text{-}4)$$

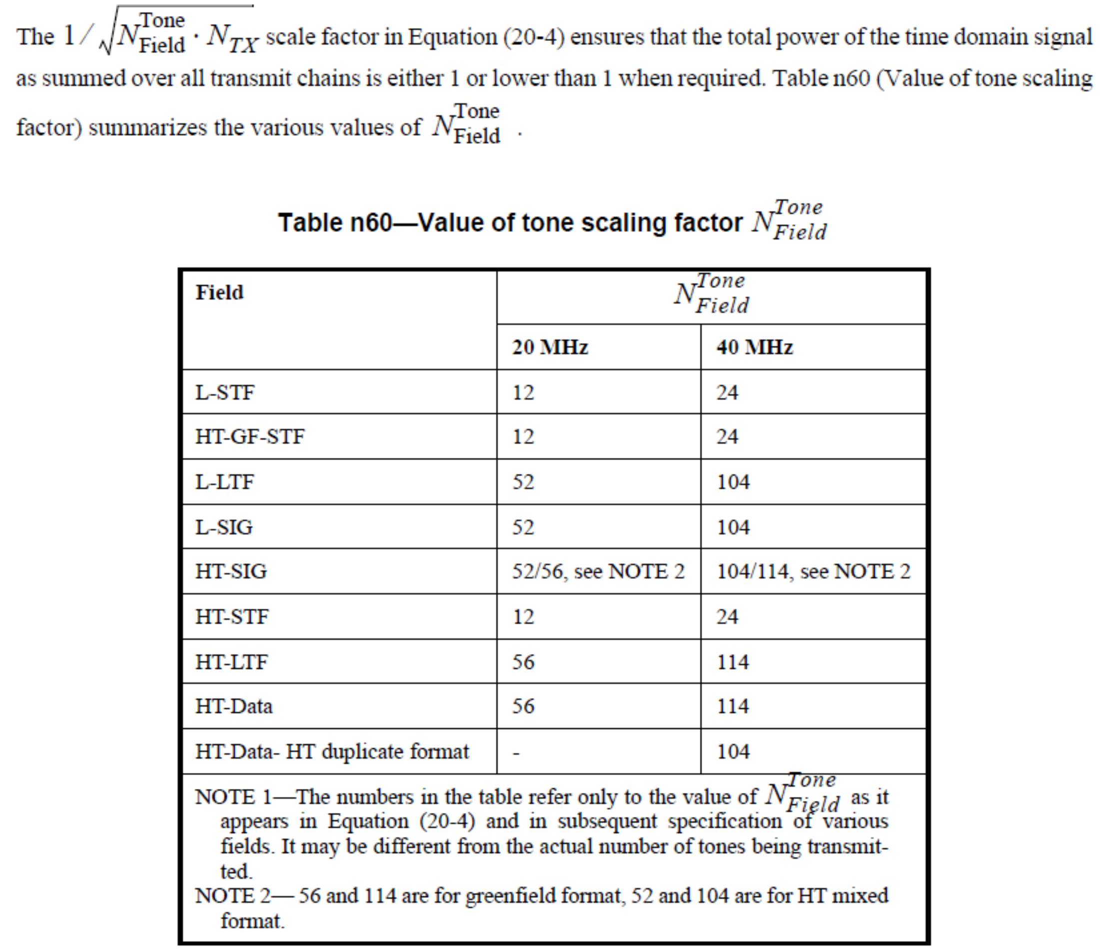
This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \quad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \quad (20\text{-}6)$$

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0



The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	**40 MHz**
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

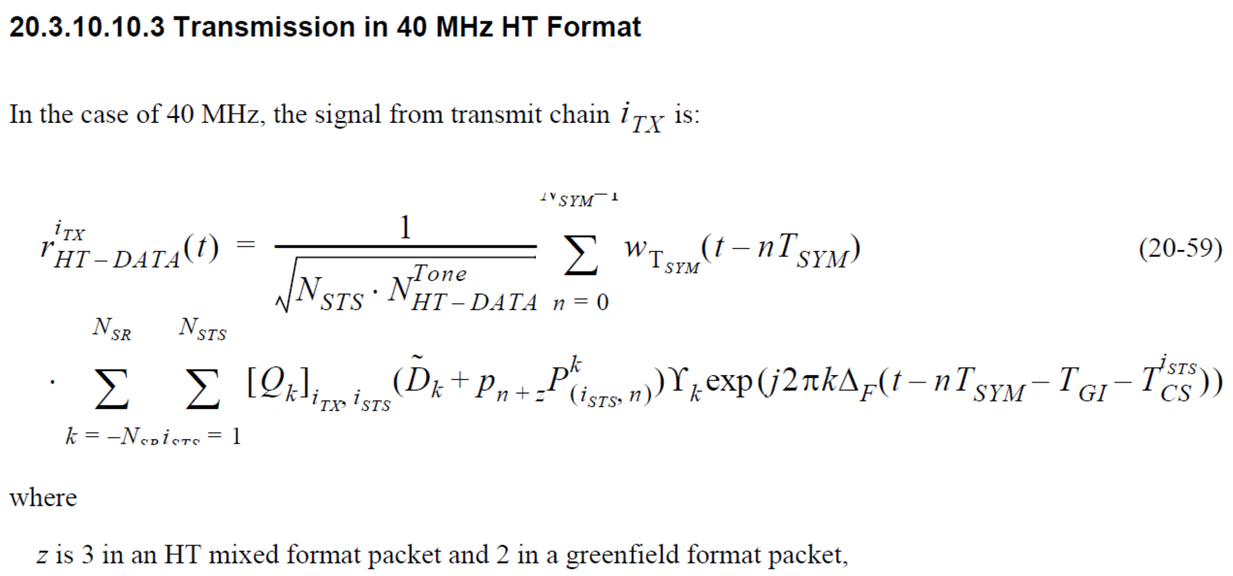
NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

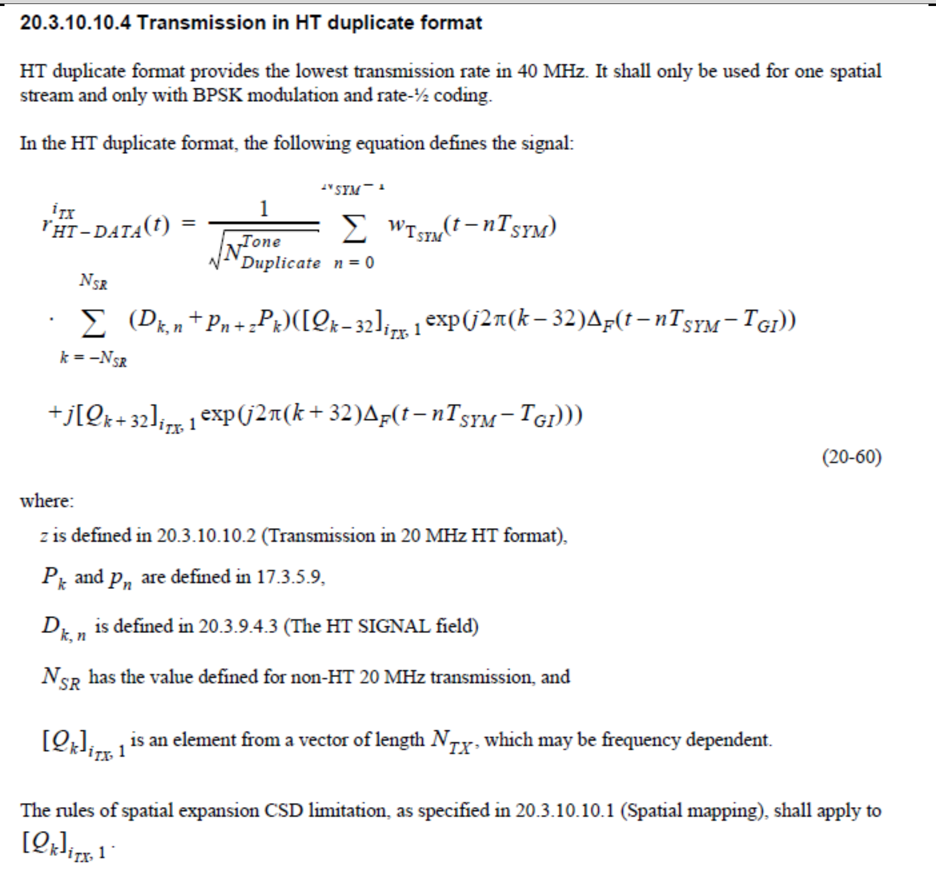
See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

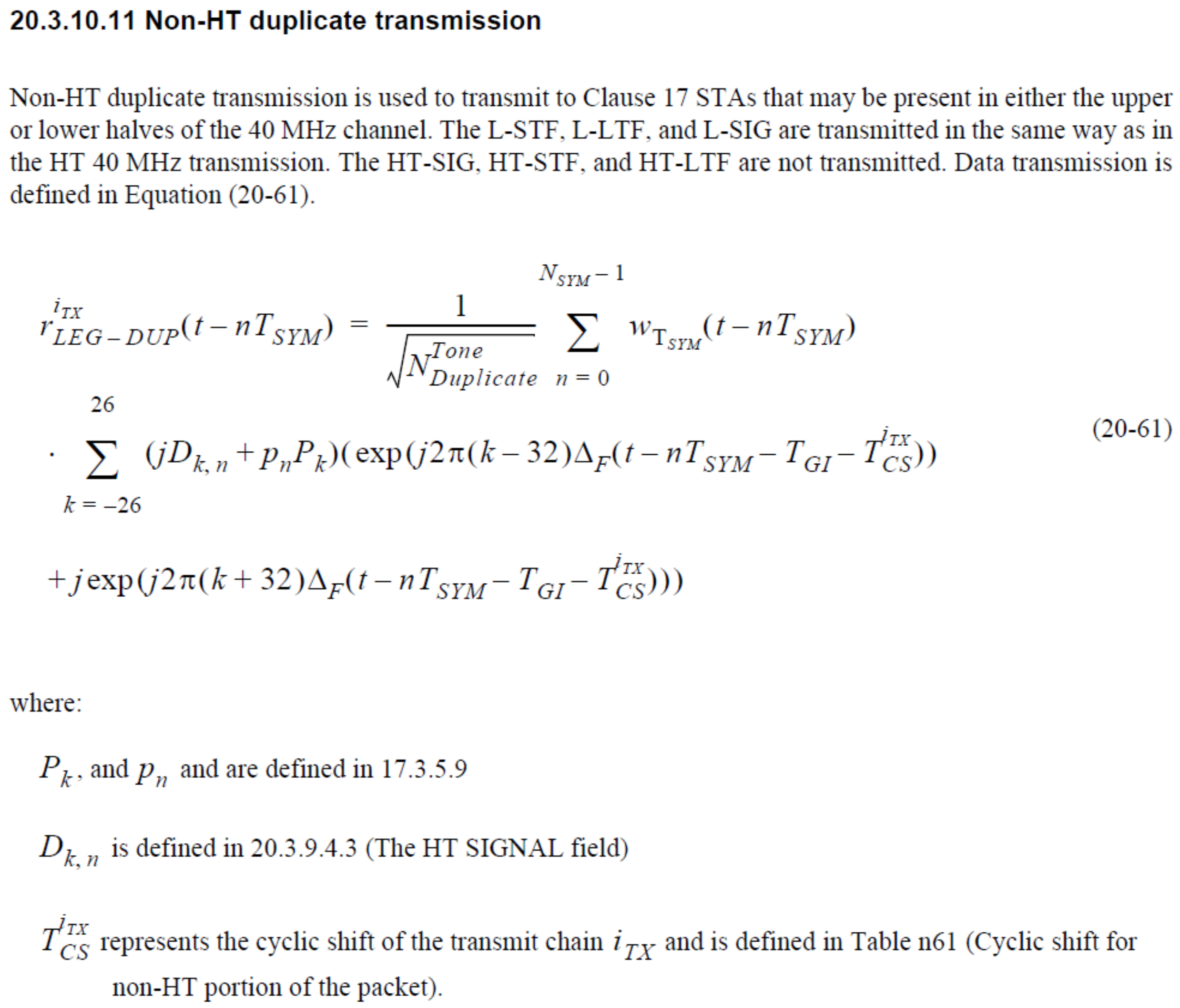
20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

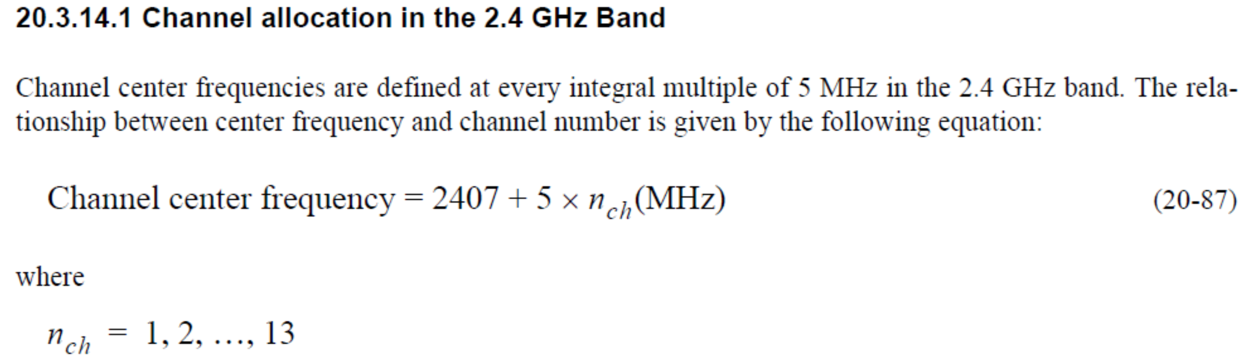
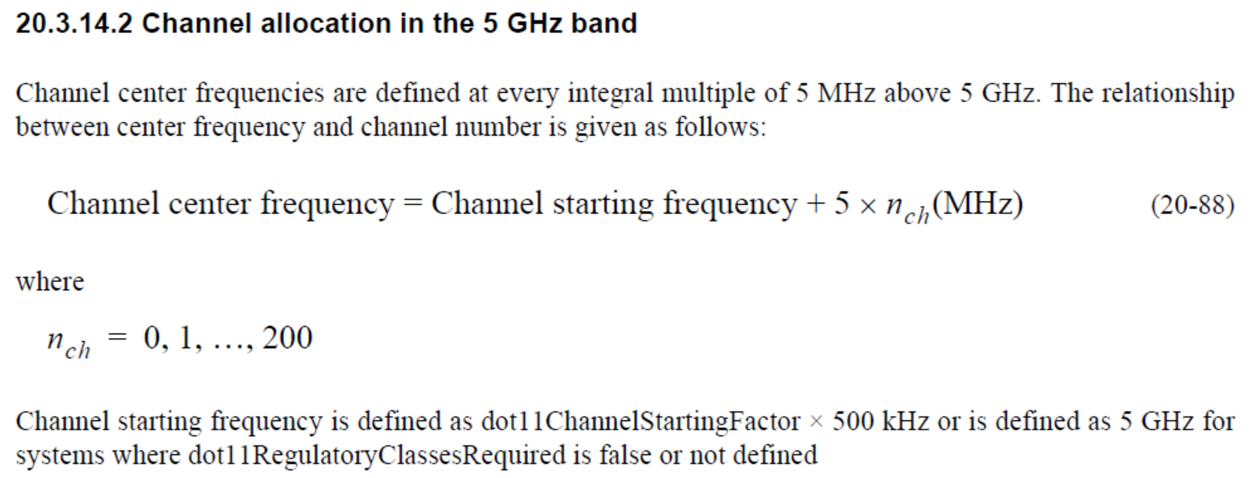
When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

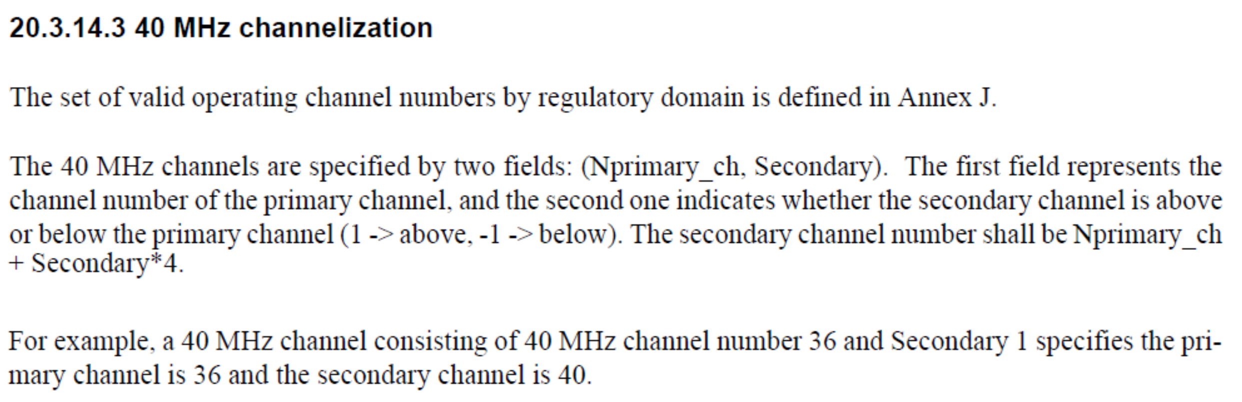
Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS} \cdot N^{Tone}_{HT-DATA}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P^k_{(i_{STS}, n)}) \exp(j 2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T^{i_{STS}}_{CS}))$ (20-58) where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

Claim 10 of the '802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $$r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{\mathrm{T}_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P_{(i_{STS}, n)}^{k}) \Upsilon_k \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}})) \qquad (20\text{-}59)$$ where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n} + p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI})) + j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

Claim 10 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r_{LEG-DUP}^{i_{TX}}(t-nT_{SYM}) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n}+p_nP_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{TX}})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{TX}})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T_{CS}^{i_{TX}}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz}) \qquad (20\text{-}87)$ where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz}) \qquad (20\text{-}88)$ where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

<table>
<tr><th>Claim 10 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>See, e.g., 802.11n D2.0 § 20.3.20.3

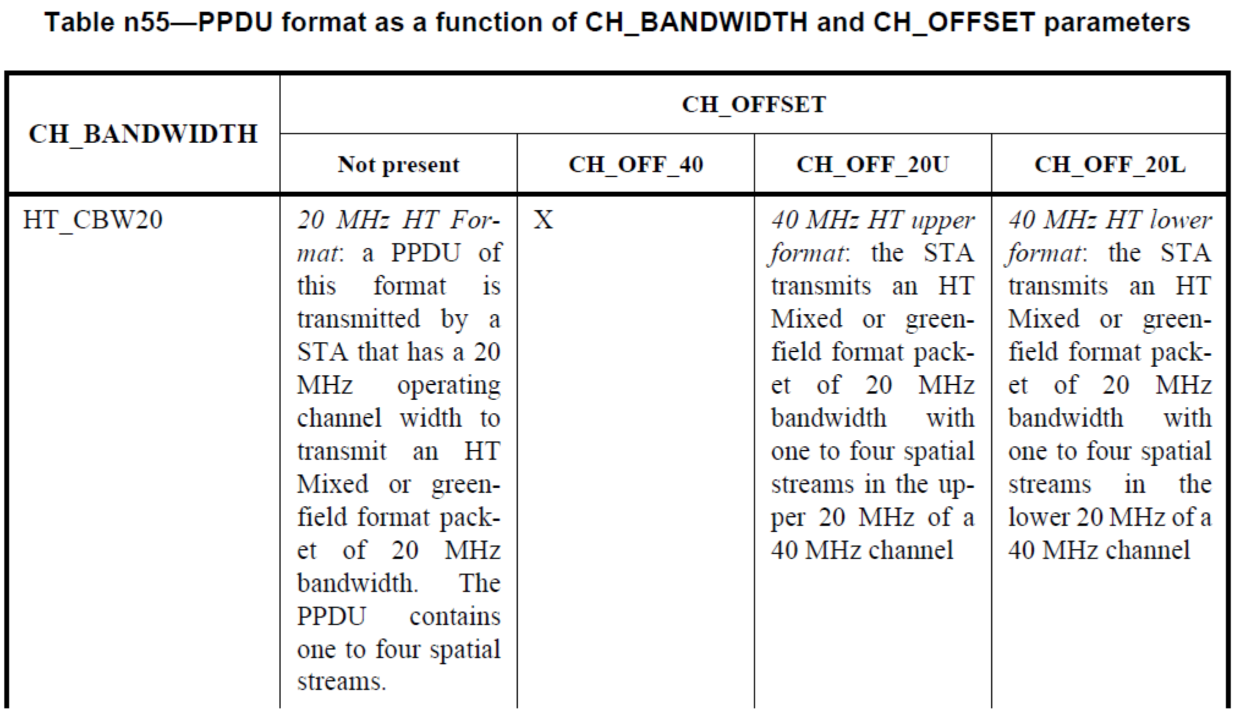
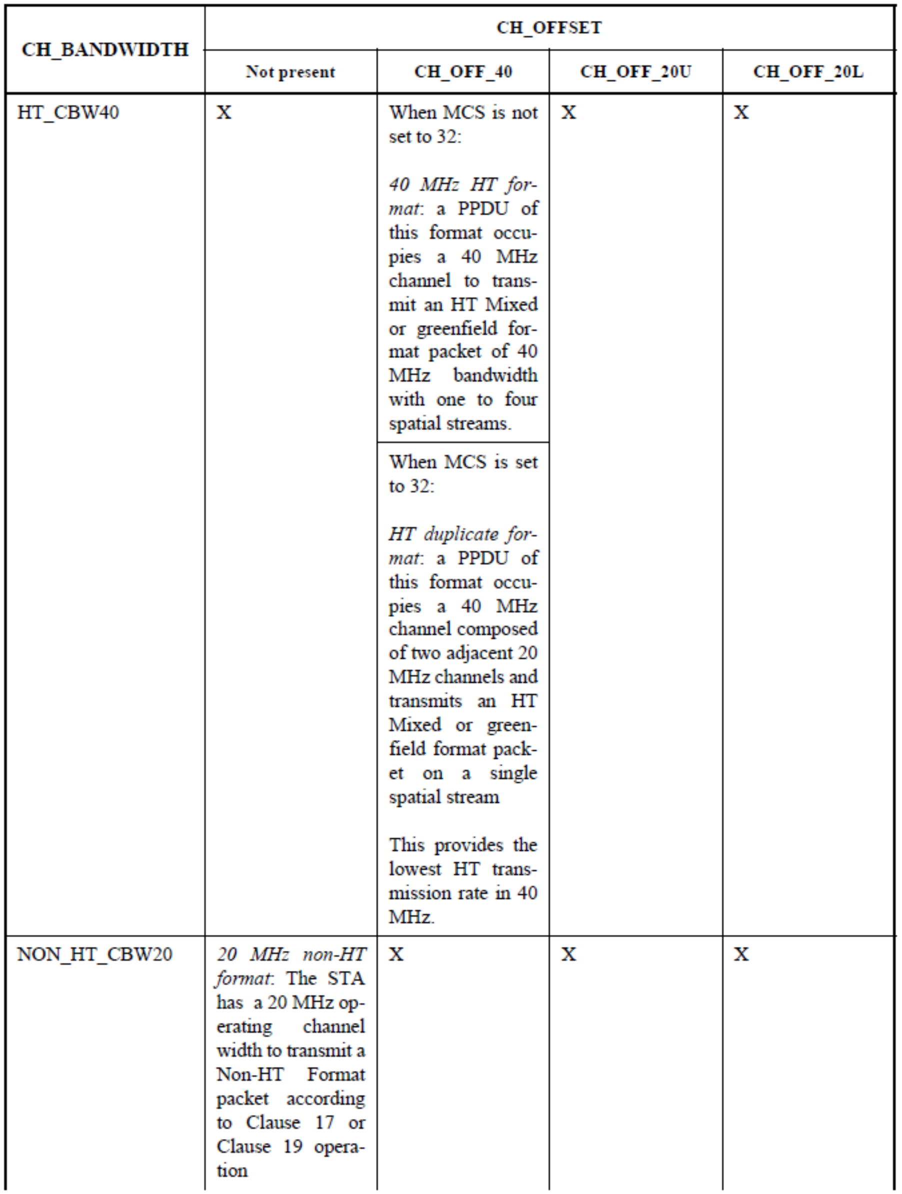
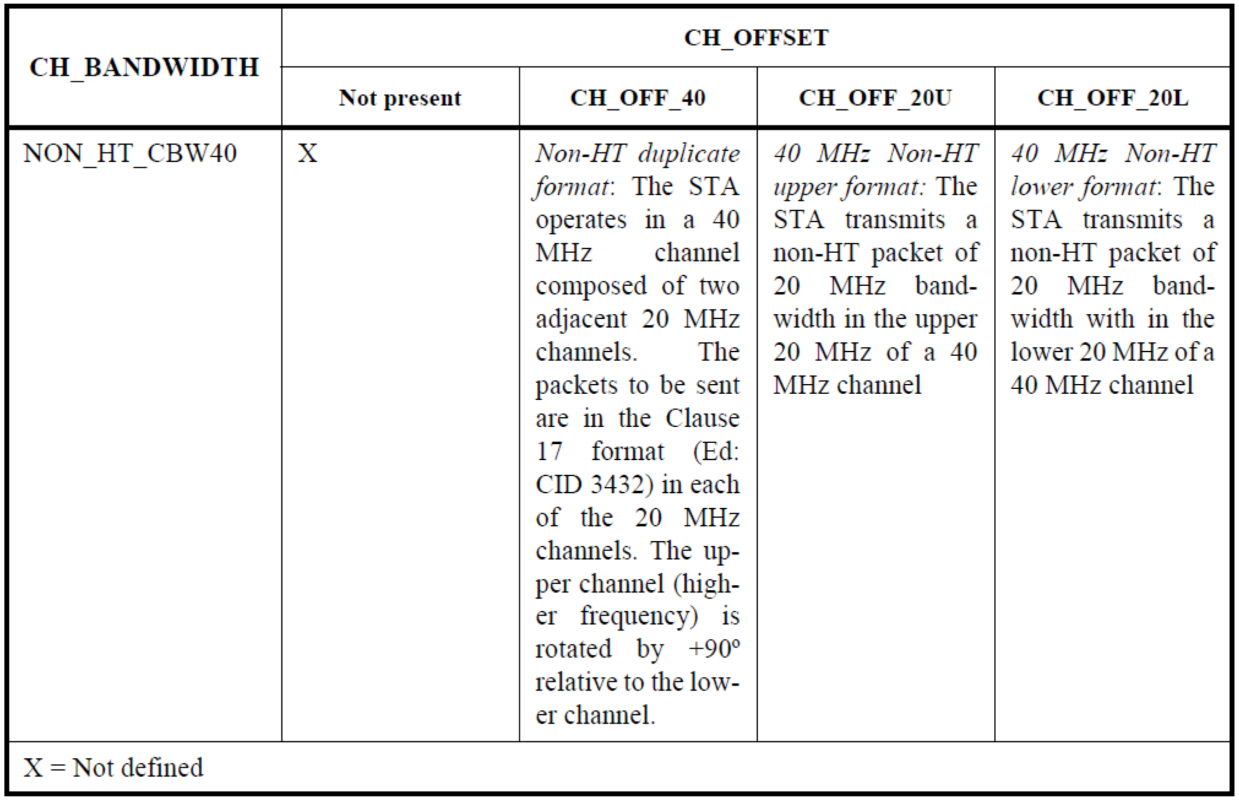



Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters
<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>HT_CBW20</td><td><i>20 MHz HT Format</i>: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or green-field format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.</td><td>X</td><td><i>40 MHz HT upper format</i>: the STA transmits an HT Mixed or green-field format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel</td><td><i>40 MHz HT lower format</i>: the STA transmits an HT Mixed or green-field format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel</td></tr>
</table>
</td></tr>
</table>



CH_BANDWIDTH	**CH_OFFSET**			
	Not present	**CH_OFF_40**	**CH_OFF_20U**	**CH_OFF_20L**
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams.	X	X
		When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.		
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

<table>
<tr><th>Claim 10 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>NON_HT_CBW40</td><td>X</td><td><i>Non-HT duplicate format</i>: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.</td><td><i>40 MHz Non-HT upper format:</i> The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel</td><td><i>40 MHz Non-HT lower format</i>: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel</td></tr>
<tr><td colspan="5">X = Not defined</td></tr>
</table>

See, e.g., 802.11n D2.0 Table n55
</td></tr>
</table>

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0

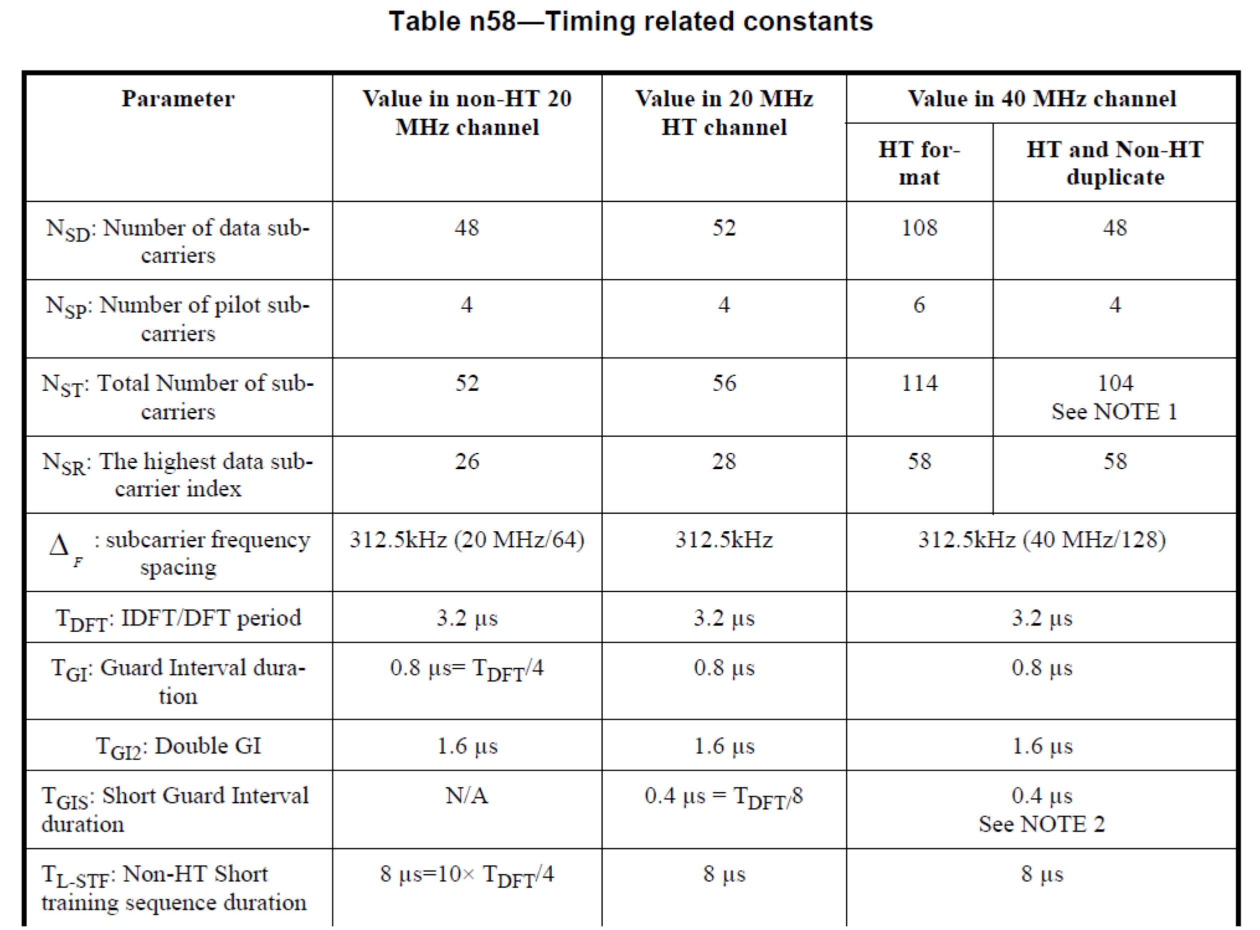
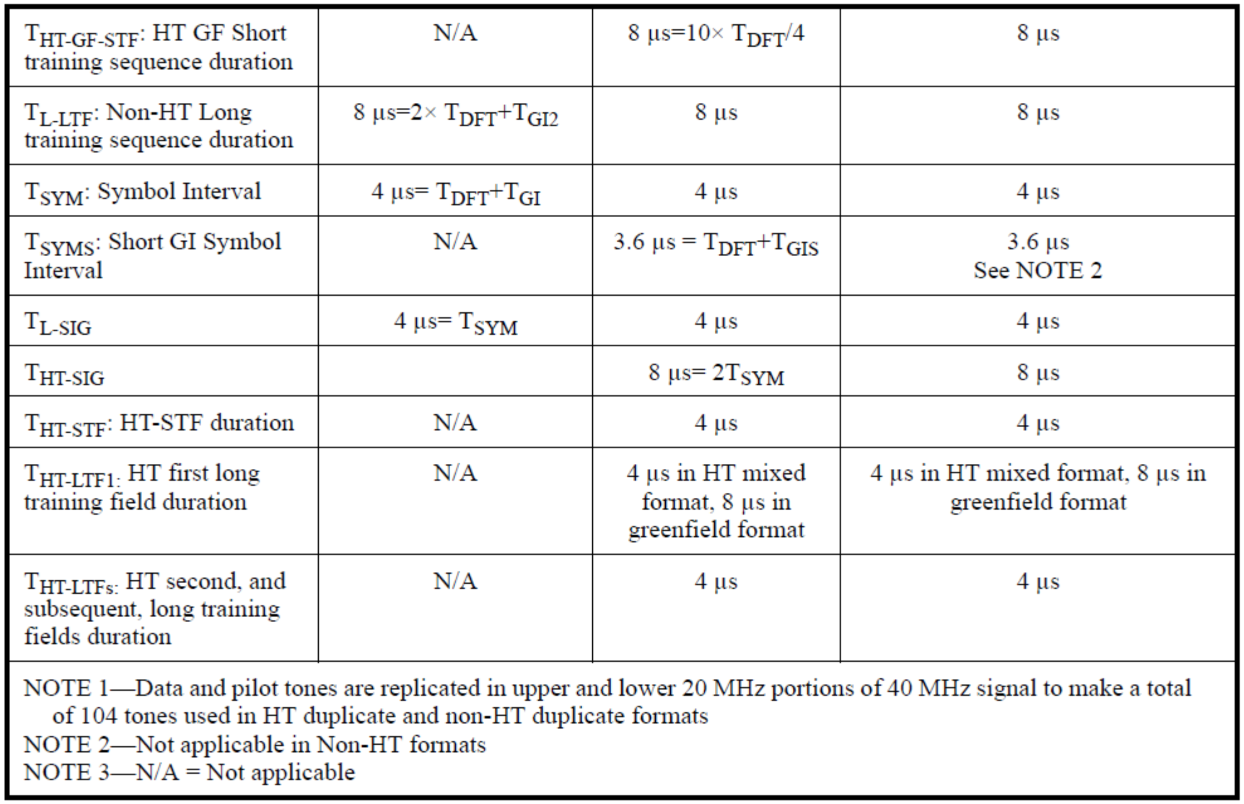


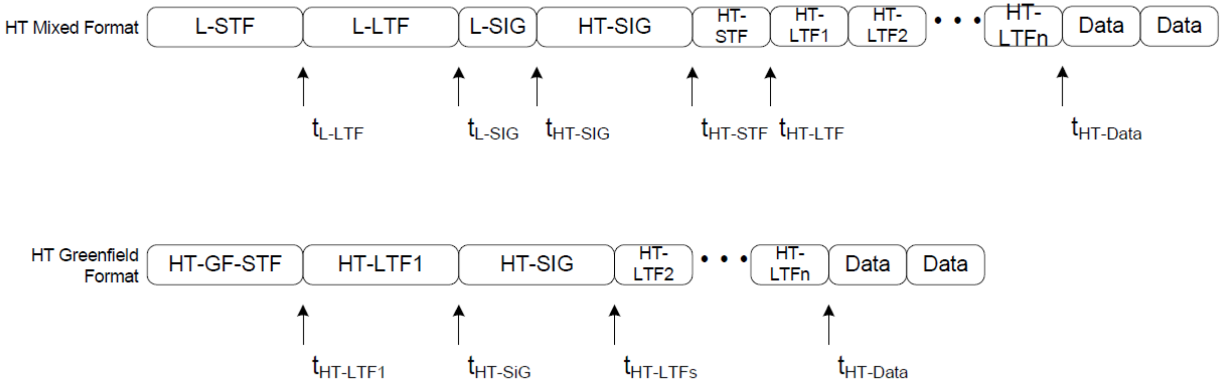
Table n58—Timing related constants

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

Claim 10 of the '802 Patent	**Prior Art Reference – 802.11n D2.0**
	 See, e.g., 802.11n D2.0 Table n58

$T_{HT\text{-}GF\text{-}STF}$: HT GF Short training sequence duration	N/A	8 μs=10× T_{DFT}/4	8 μs
$T_{L\text{-}LTF}$: Non-HT Long training sequence duration	8 μs=2× T_{DFT}+T_{GI2}	8 μs	8 μs
T_{SYM}: Symbol Interval	4 μs= T_{DFT}+T_{GI}	4 μs	4 μs
T_{SYMS}: Short GI Symbol Interval	N/A	3.6 μs = T_{DFT}+T_{GIS}	3.6 μs See NOTE 2
$T_{L\text{-}SIG}$	4 μs= T_{SYM}	4 μs	4 μs
$T_{HT\text{-}SIG}$		8 μs= 2T_{SYM}	8 μs
$T_{HT\text{-}STF}$: HT-STF duration	N/A	4 μs	4 μs
$T_{HT\text{-}LTF1}$: HT first long training field duration	N/A	4 μs in HT mixed format, 8 μs in greenfield format	4 μs in HT mixed format, 8 μs in greenfield format
$T_{HT\text{-}LTFs}$: HT second, and subsequent, long training fields duration	N/A	4 μs	4 μs

NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable

Claim 10 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.
[10.5] converting the second digital signal into a second analog signal using a second digital-to-analog converter, the second analog signal carrying the second data	802.11n D2.0 discloses “converting the second digital signal into a second analog signal using a second digital-to-analog converter, the second analog signal carrying the second data across a second frequency range.” See, e.g.: **high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
across a second frequency range;	**non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

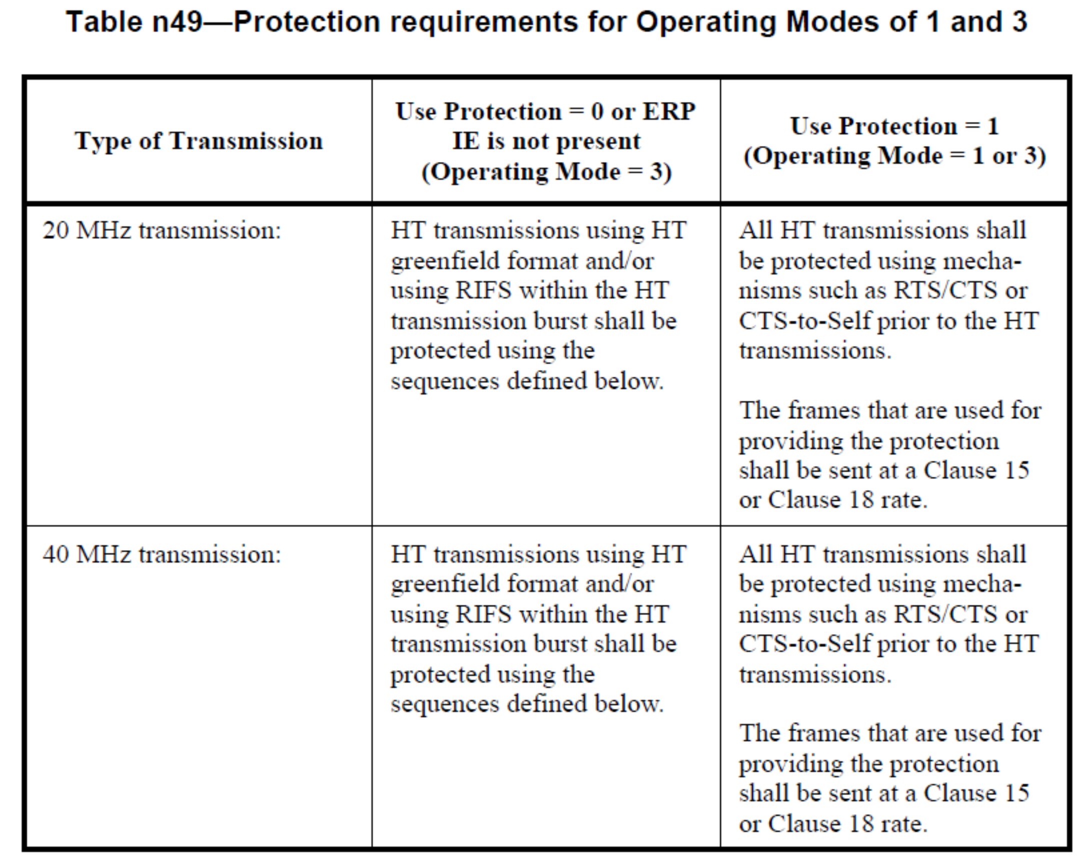
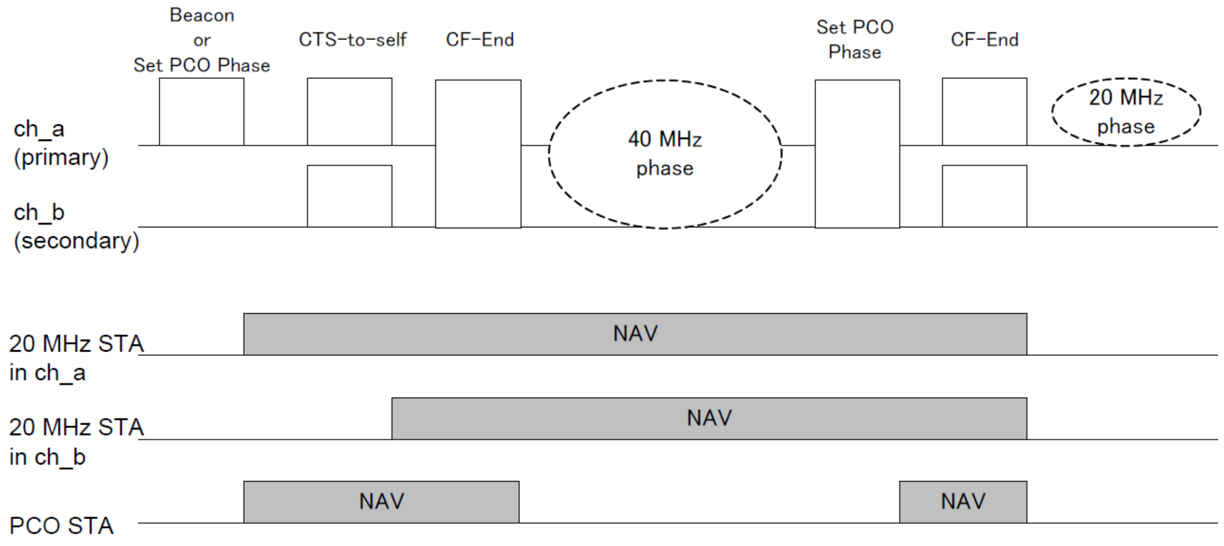
<table>
<tr><th>Claim 10 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>


Table n49—Protection requirements for Operating Modes of 1 and 3

<table>
<tr><th>Type of Transmission</th><th>Use Protection = 0 or ERP IE is not present (Operating Mode = 3)</th><th>Use Protection = 1 (Operating Mode = 1 or 3)</th></tr>
<tr><td>20 MHz transmission:</td><td>HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.</td><td>All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions.
The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.</td></tr>
<tr><td>40 MHz transmission:</td><td>HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.</td><td>All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions.
The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.</td></tr>
</table>

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.
NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).
</td></tr>
</table>

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

<table>
<tr><th>Claim 10 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>


A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU.

During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel.

During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS.

A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS.

The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.
</td></tr>
</table>

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

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	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

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	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

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	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

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	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t\right)\right\}$ (20-1) where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

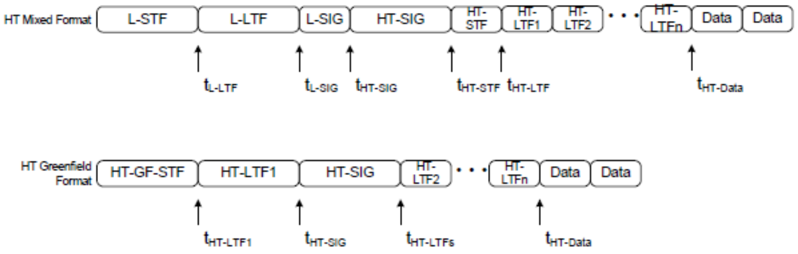

Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) &= r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ &\quad + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ &\quad + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ &\quad + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ &\quad + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right)T_{HT-LTFs}\right) \\ &\quad + r_{HT-DATA}^{(i_{TX})}\left(t - t_{HT-DATA}\right) \end{aligned} \tag{20-2}$$

where

$$t_{L-LTF} = T_{L-STF}$$

$$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$$

$$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$$

$$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r^{(i_{TX})}_{PPDU}(t) = {} & r^{(i_{TX})}_{HT-GF-STF}(t) + r^{(i_{TX})}_{HT-LTF1}(t - t_{HT-LTF1}) \\ & + r^{(i_{TX})}_{HT-SIG}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r^{(i_{TX}, i_{LTF})}_{HT-LTF}(t - t_{HT-LTFs} - (i_{LTF} - 2)T_{HT-LTFs}) \\ & + r^{(i_{TX})}_{HT-DATA}(t - t_{HT-DATA}) \end{aligned} \quad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r^{(i_{TX})}_{\text{Field}}(t)$, is defined via the discrete Fourier transform as

$$r^{(i_{TX})}_{\text{Field}}(t) = \frac{1}{\sqrt{N^{\text{Tone}}_{\text{Field}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X^{(i_{TX})}_k \exp(j2\pi k \Delta_F t) \quad (20\text{-}4)$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X^{(i_{TX})}_k$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \quad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \quad (20\text{-}6)$$

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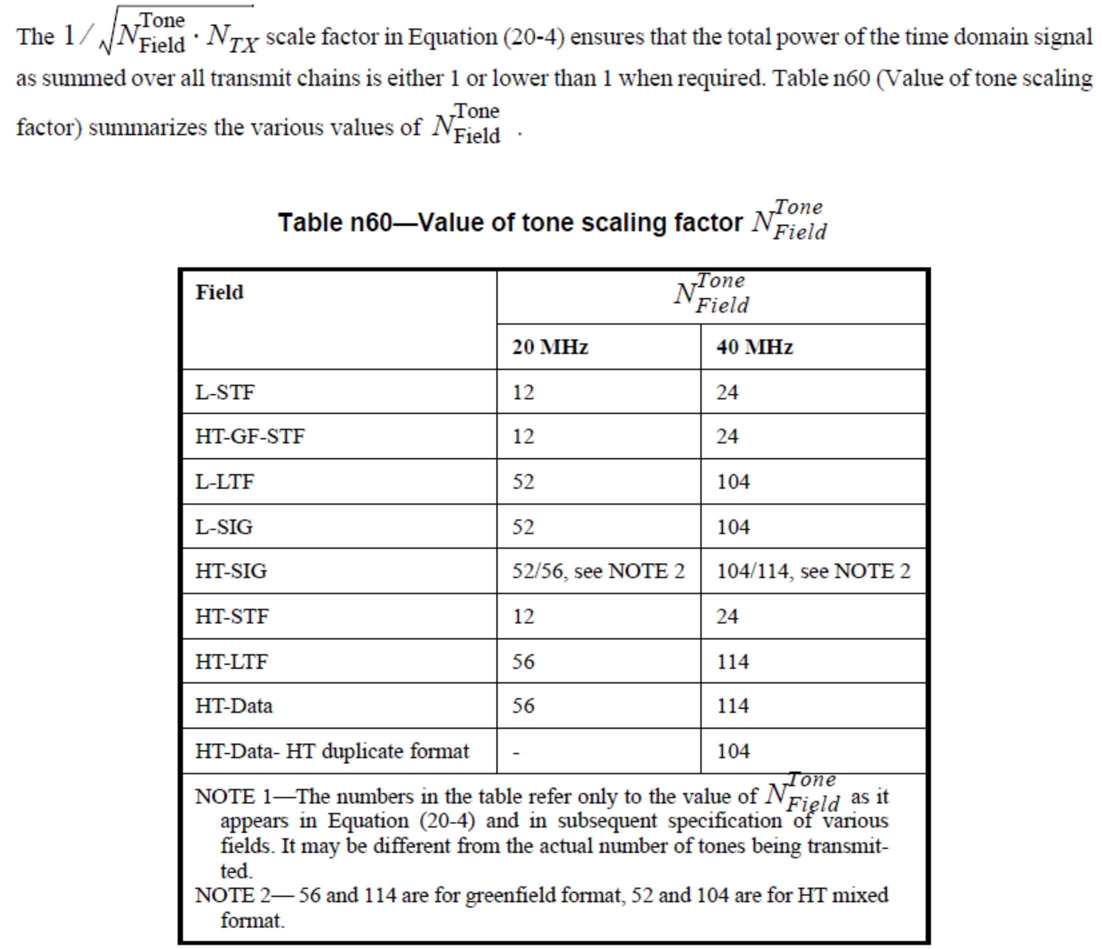
	(excerpt below)



The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	**40 MHz**
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

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	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS} \cdot N^{Tone}_{HT-DATA}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM})$ (20-58) $\cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P^k_{(i_{STS}, n)}) \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T^{i_{STS}}_{CS}))$ where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

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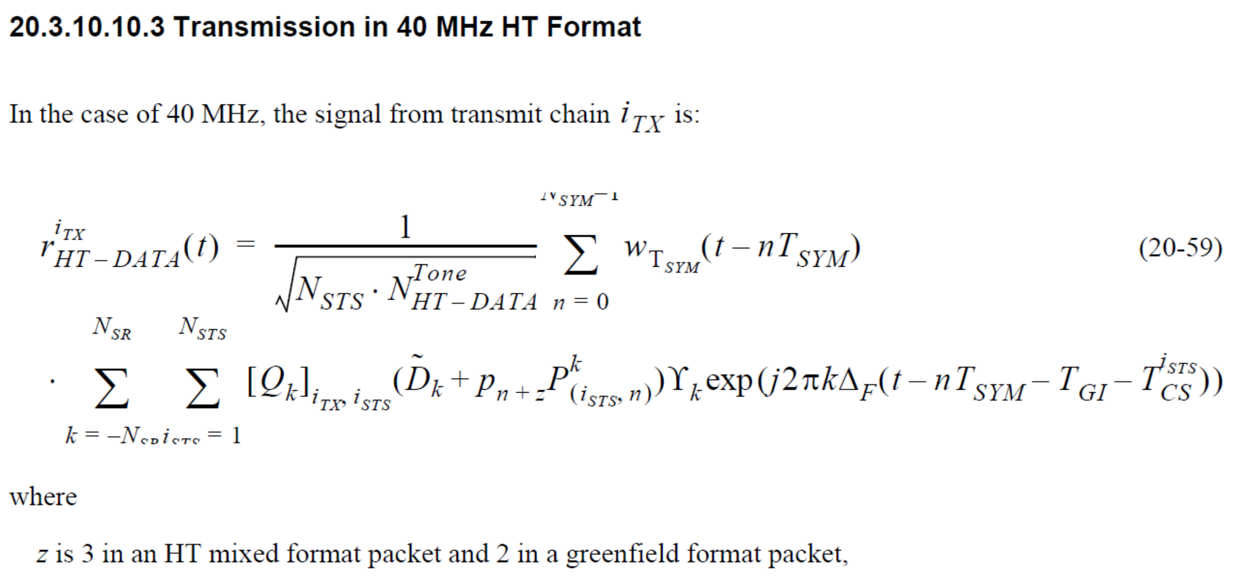
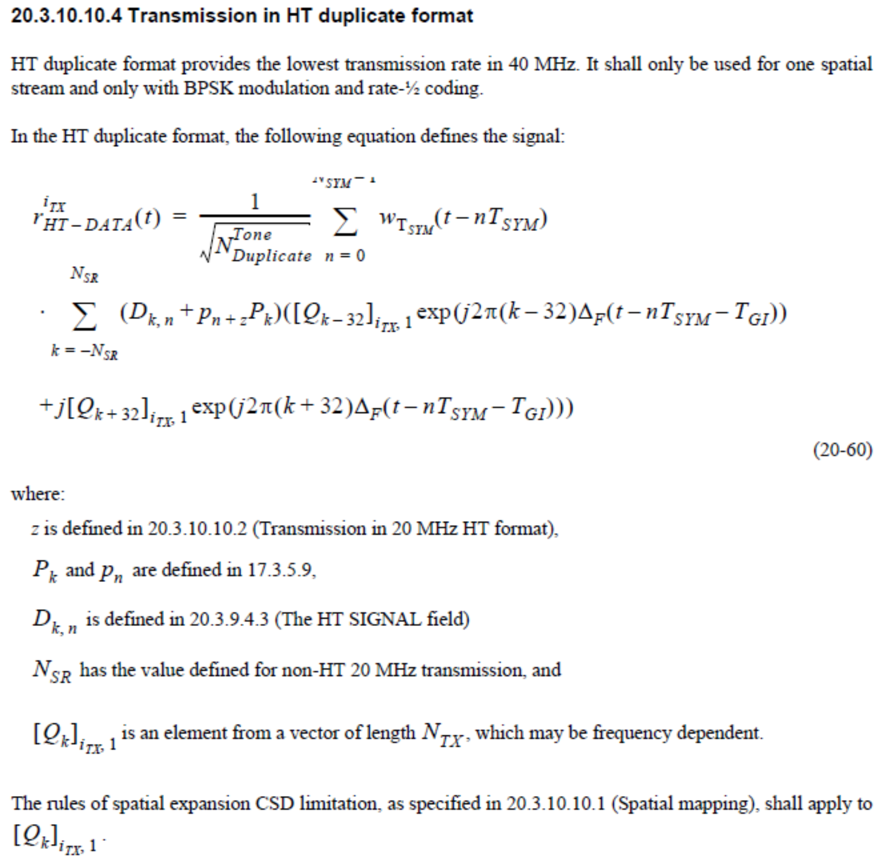
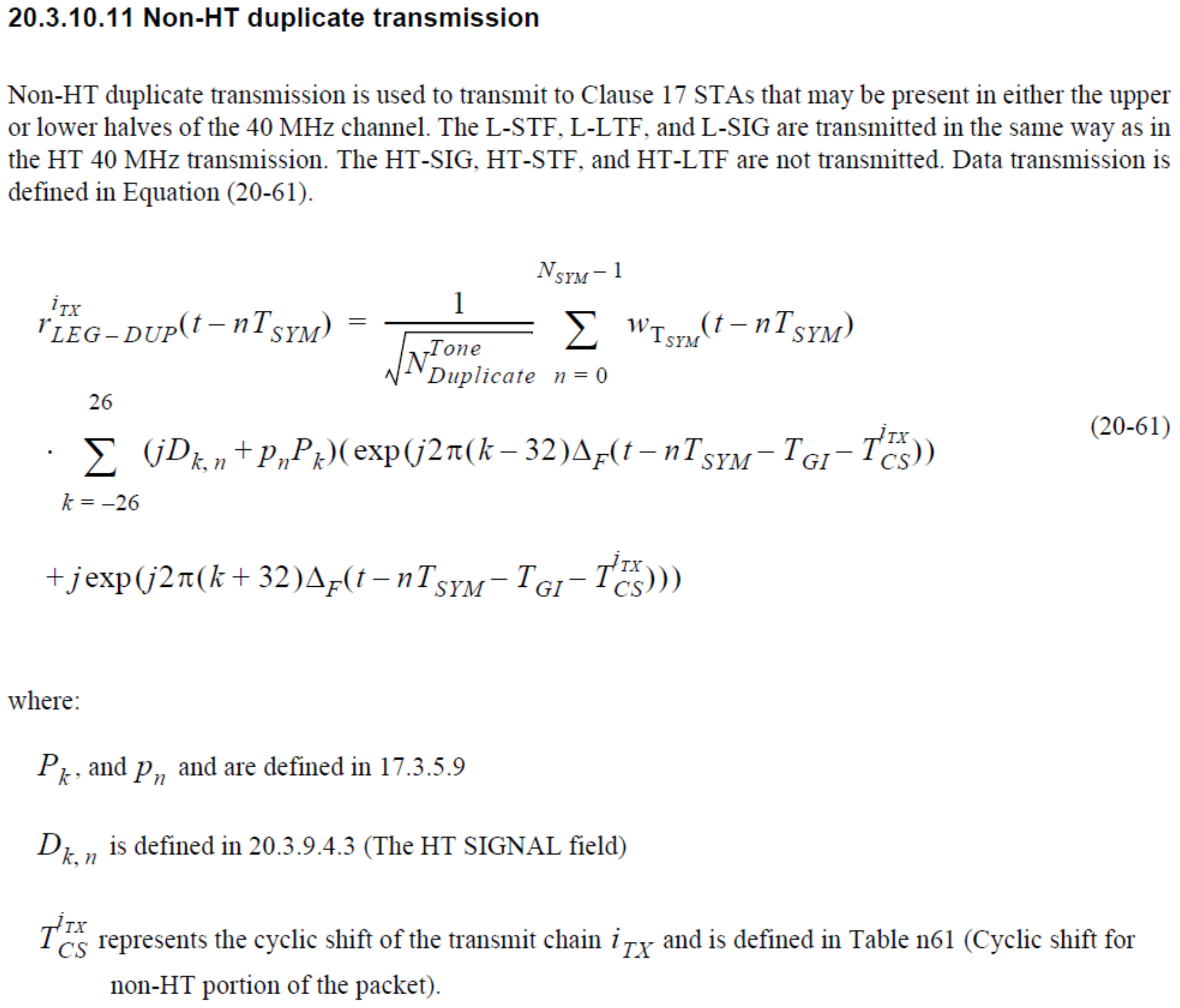
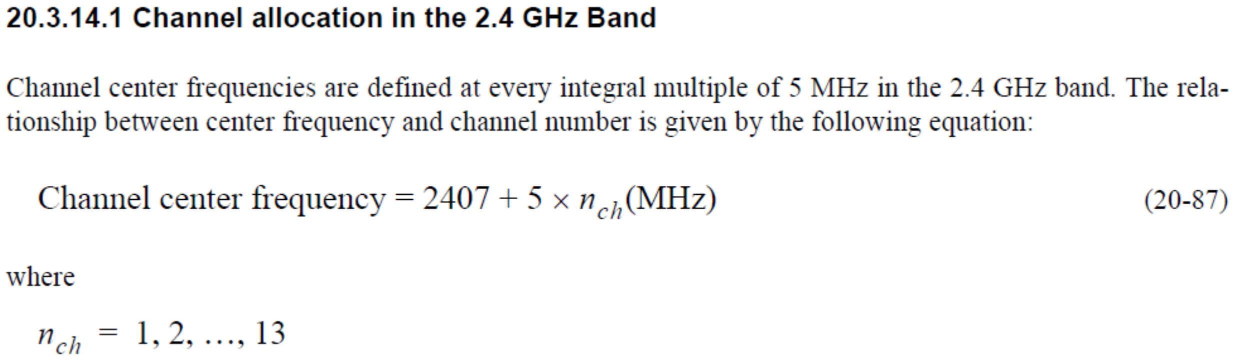
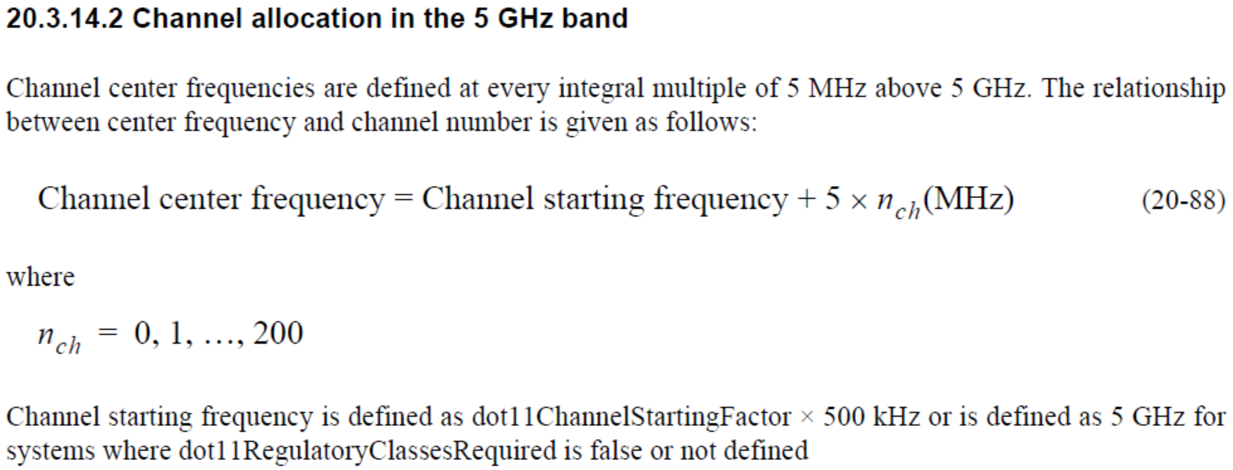
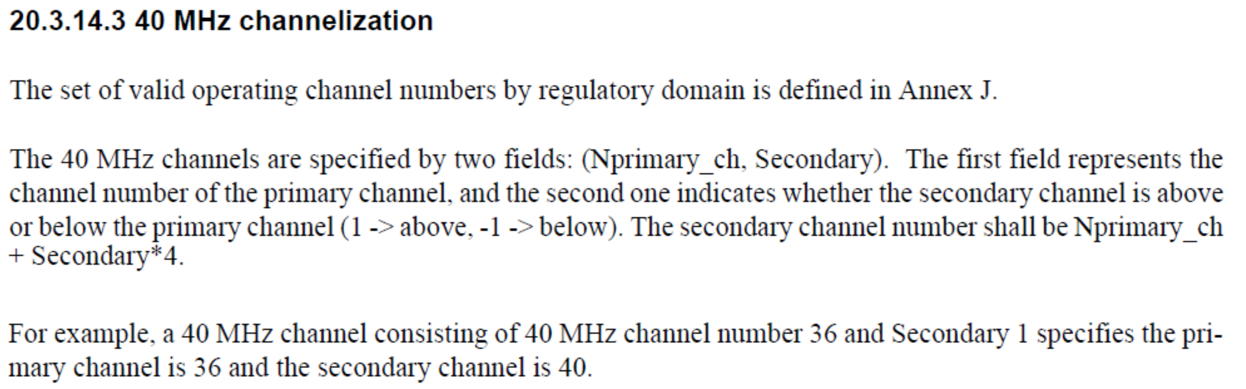
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P^k_{(i_{STS}, n)}) \Upsilon_k \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (20-59) where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n}+p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI})) + j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r^{i_{TX}}_{LEG-DUP}(t-nT_{SYM}) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}}\sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26}(jD_{k,n}+p_nP_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{TX}})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{TX}})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T_{CS}^{i_{TX}}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch} (\text{MHz}) \quad (20\text{-}87)$ where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch} (\text{MHz}) \quad (20\text{-}88)$ where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.20.3

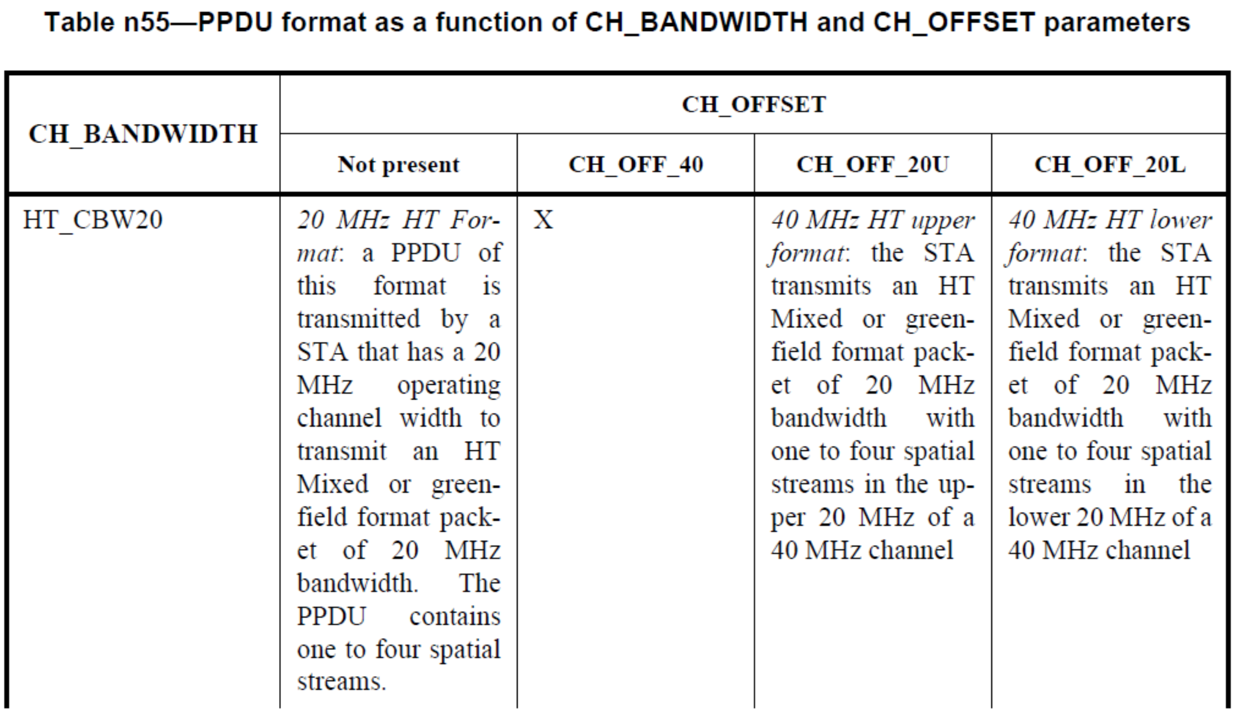
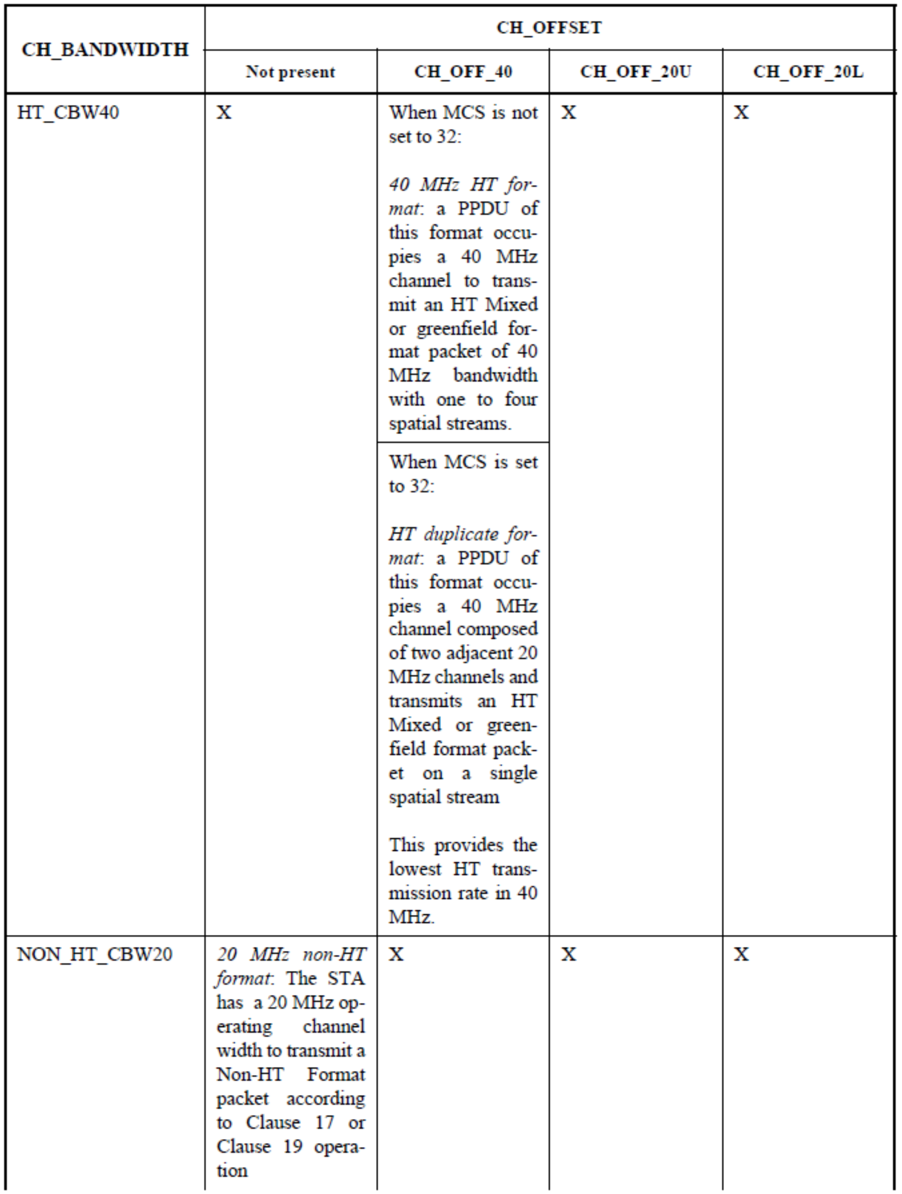
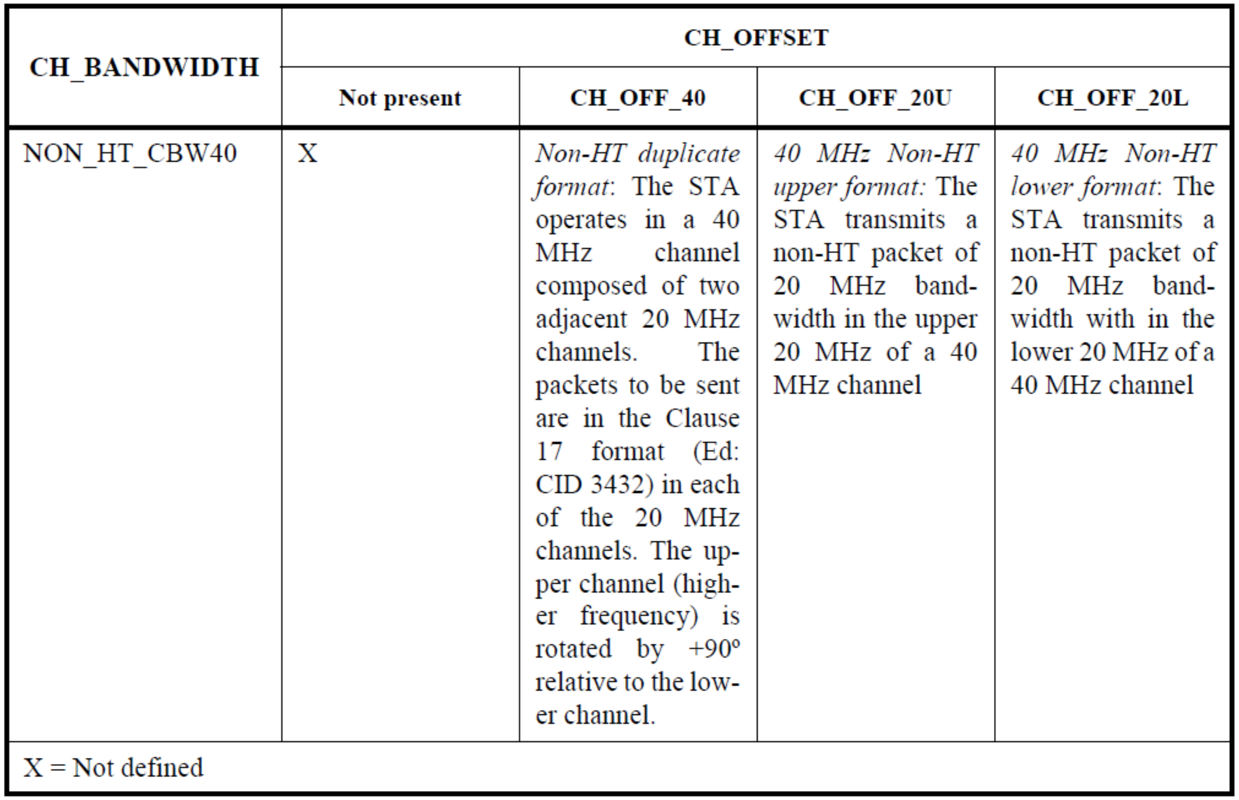


Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or green-field format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or green-field format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or green-field format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel



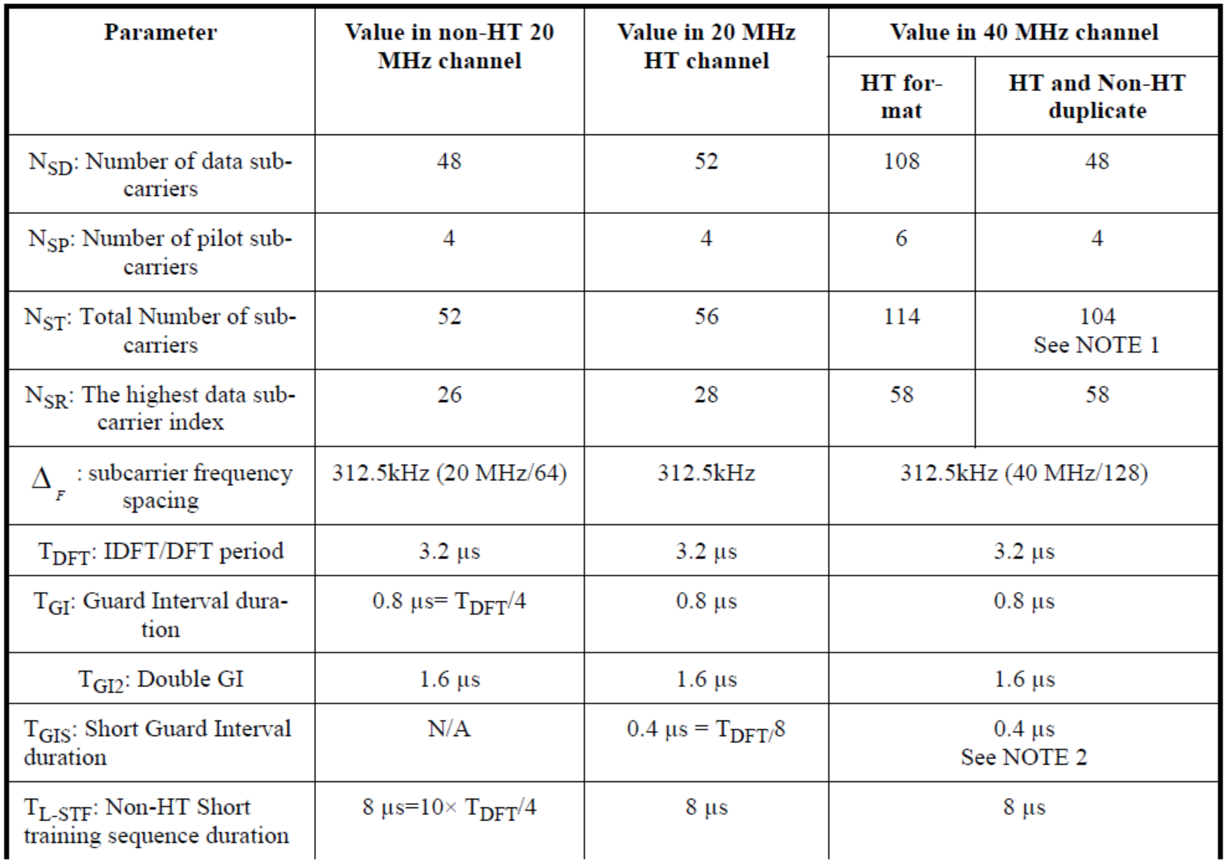
CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams.	X	X
		When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.		
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

Claim 10 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 See, e.g., 802.11n D2.0 Table n55

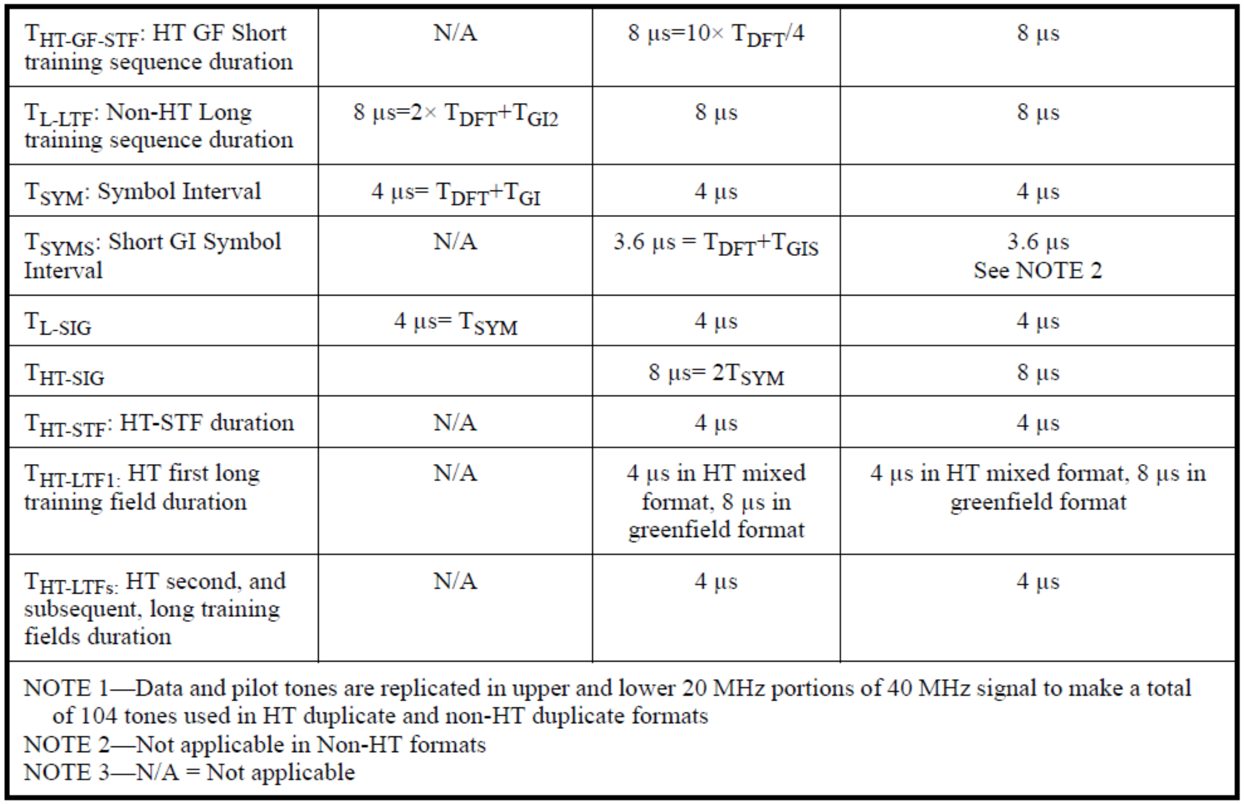
CH_BANDWIDTH	**CH_OFFSET**			
	Not present	**CH_OFF_40**	**CH_OFF_20U**	**CH_OFF_20L**
NON_HT_CBW40	X	*Non-HT duplicate format*: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.	*40 MHz Non-HT upper format:* The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel	*40 MHz Non-HT lower format*: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel
X = Not defined				

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0

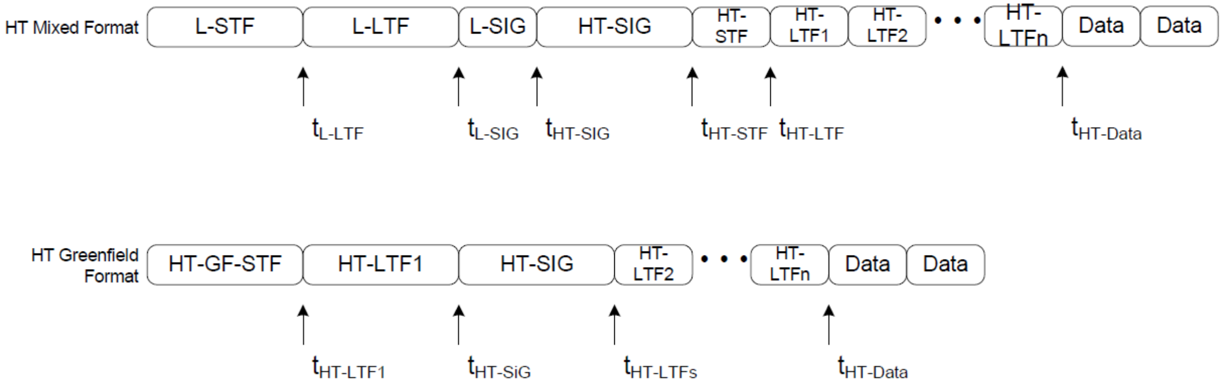
Table n58—Timing related constants



Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= T_{DFT}/4	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = T_{DFT}/8	0.4 µs See NOTE 2	
T_{L-STF}: Non-HT Short training sequence duration	8 µs=10× T_{DFT}/4	8 µs	8 µs	

<table>
<tr><th>Claim 10 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><td>$T_{HT-GF-STF}$: HT GF Short training sequence duration</td><td>N/A</td><td>8 μs=10× T_{DFT}/4</td><td>8 μs</td></tr>
<tr><td>T_{L-LTF}: Non-HT Long training sequence duration</td><td>8 μs=2× T_{DFT}+T_{GI2}</td><td>8 μs</td><td>8 μs</td></tr>
<tr><td>T_{SYM}: Symbol Interval</td><td>4 μs= T_{DFT}+T_{GI}</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td>T_{SYMS}: Short GI Symbol Interval</td><td>N/A</td><td>3.6 μs = T_{DFT}+T_{GIS}</td><td>3.6 μs
See NOTE 2</td></tr>
<tr><td>T_{L-SIG}</td><td>4 μs= T_{SYM}</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td>T_{HT-SIG}</td><td></td><td>8 μs= 2T_{SYM}</td><td>8 μs</td></tr>
<tr><td>T_{HT-STF}: HT-STF duration</td><td>N/A</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td>$T_{HT-LTF1:}$ HT first long training field duration</td><td>N/A</td><td>4 μs in HT mixed format, 8 μs in greenfield format</td><td>4 μs in HT mixed format, 8 μs in greenfield format</td></tr>
<tr><td>$T_{HT-LTFs:}$ HT second, and subsequent, long training fields duration</td><td>N/A</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td colspan="4">NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable</td></tr>
</table>

See, e.g., 802.11n D2.0 Table n58
</td></tr>
</table>

Claim 10 of the '802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.
[10.6] up-converting the first analog signal to a first RF center frequency to produce a first up-converted analog signal, wherein the first up-converted analog signal comprises a first up-converted frequency range from the first	802.11n D2.0 discloses "up-converting the first analog signal to a first RF center frequency to produce a first up-converted analog signal, wherein the first up-converted analog signal comprises a first up-converted frequency range from the first RF center frequency minus one-half the first frequency range to the first RF center frequency plus one-half the first frequency range." See, e.g.: **high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
RF center frequency minus one-half the first frequency range to the first RF center frequency plus one-half the first frequency range;	**non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

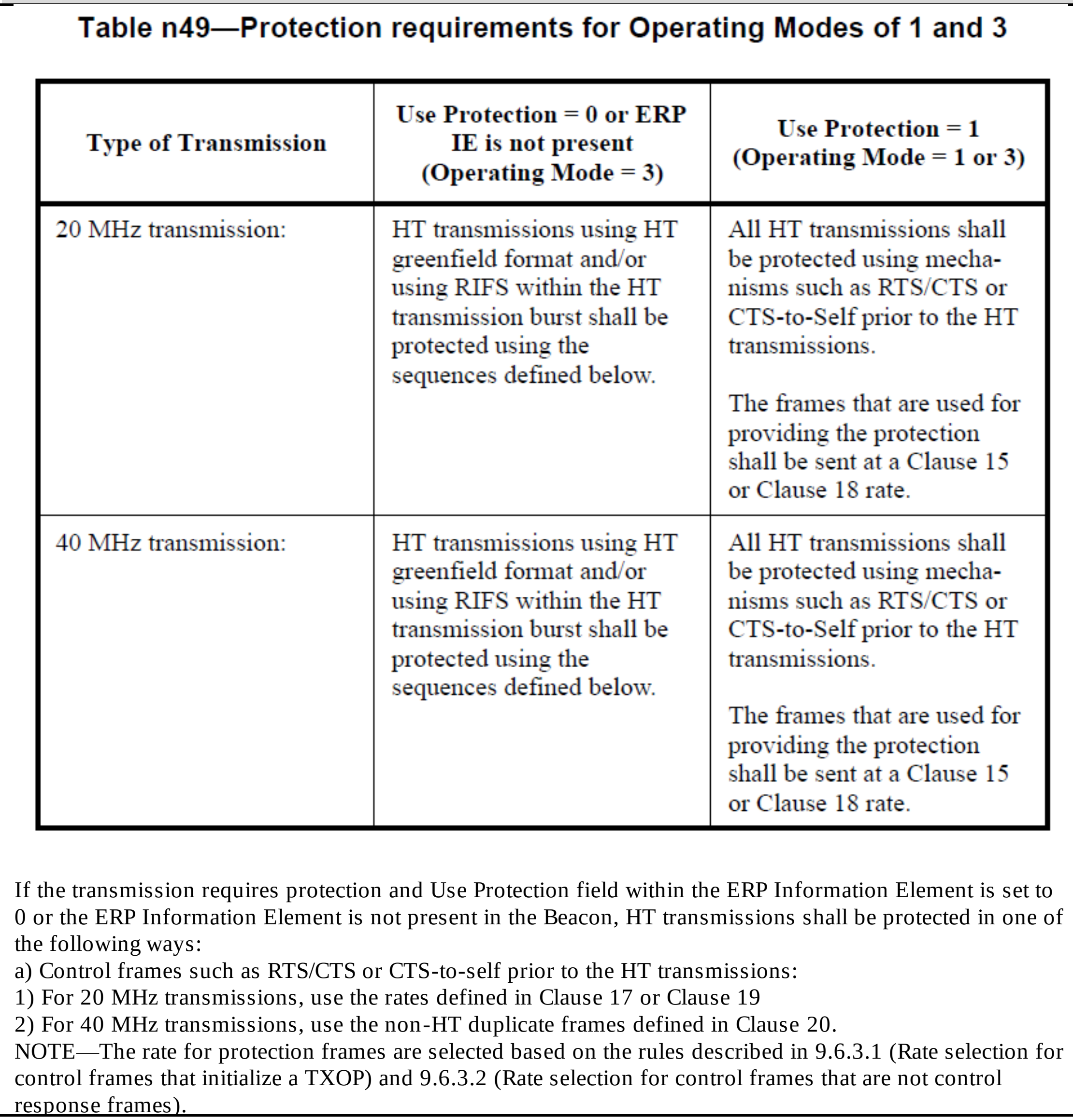
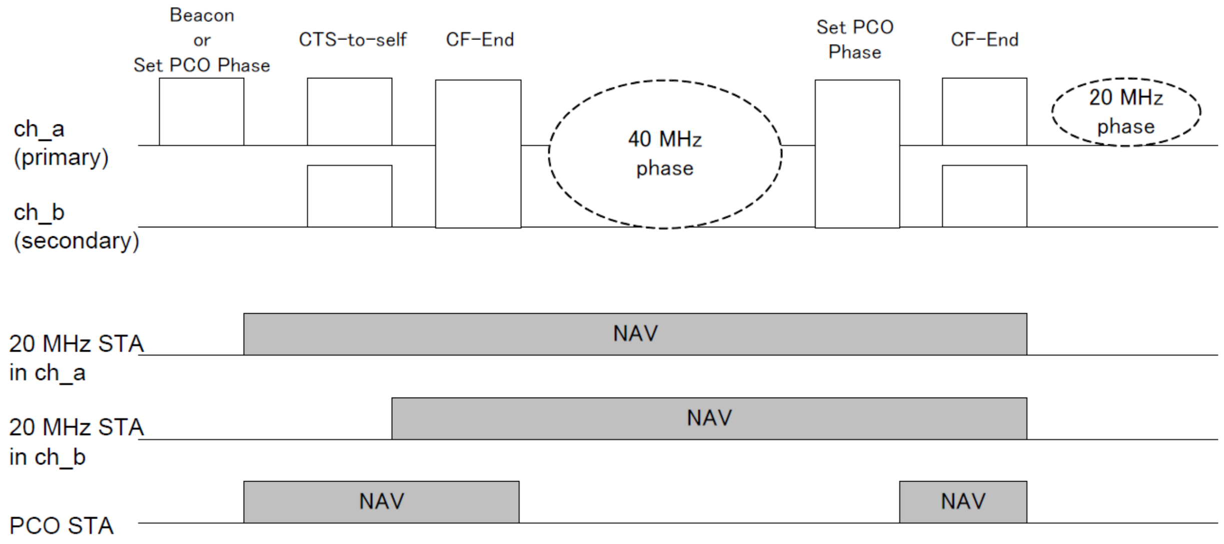
<table>
<tr><th>Claim 10 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>


Table n49—Protection requirements for Operating Modes of 1 and 3

<table>
<tr><th>Type of Transmission</th><th>Use Protection = 0 or ERP IE is not present (Operating Mode = 3)</th><th>Use Protection = 1 (Operating Mode = 1 or 3)</th></tr>
<tr><td>20 MHz transmission:</td><td>HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.</td><td>All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions.
The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.</td></tr>
<tr><td>40 MHz transmission:</td><td>HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.</td><td>All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions.
The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.</td></tr>
</table>

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.
NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).
</td></tr>
</table>

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

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	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

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	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

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	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t \right) \right\}$ (20-1) where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

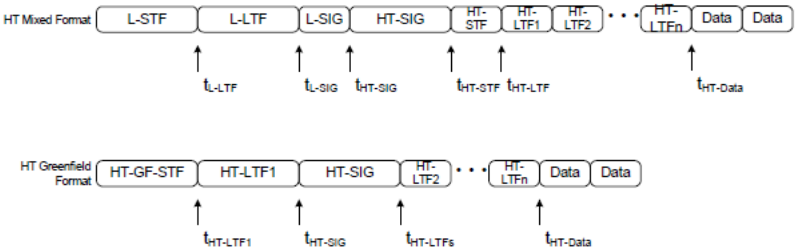

Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right)T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \tag{20-2}$$

where

$$t_{L-LTF} = T_{L-STF}$$

$$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$$

$$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$$

$$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1}) \\ & + r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2) T_{HT-LTFs}) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \qquad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\text{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\text{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j 2\pi k \Delta_F t) \qquad (20\text{-}4)$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \qquad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \qquad (20\text{-}6)$$

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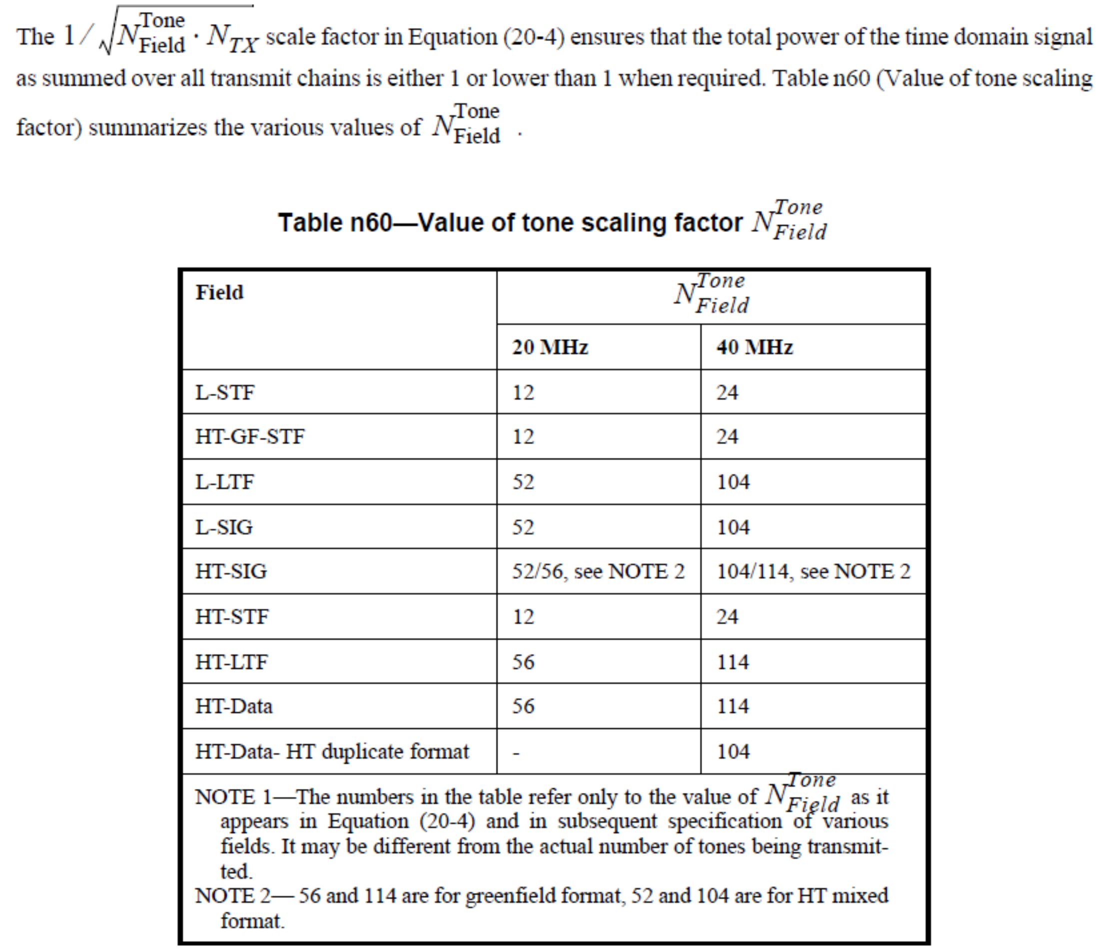

The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	40 MHz
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

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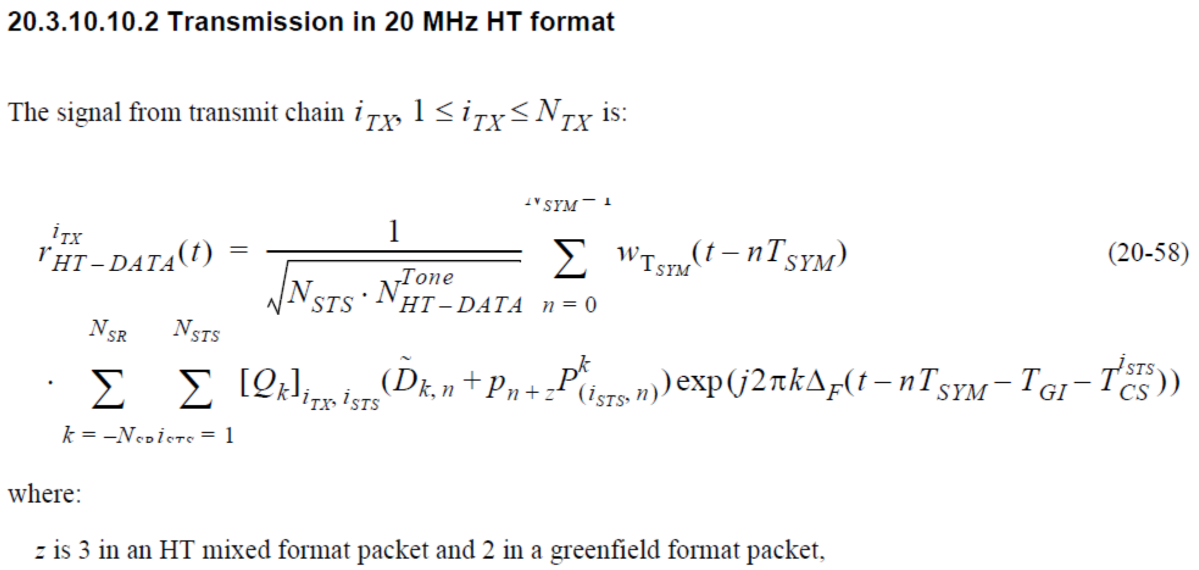
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3  **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P_{(i_{STS},n)}^{k}) \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (20-58) where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

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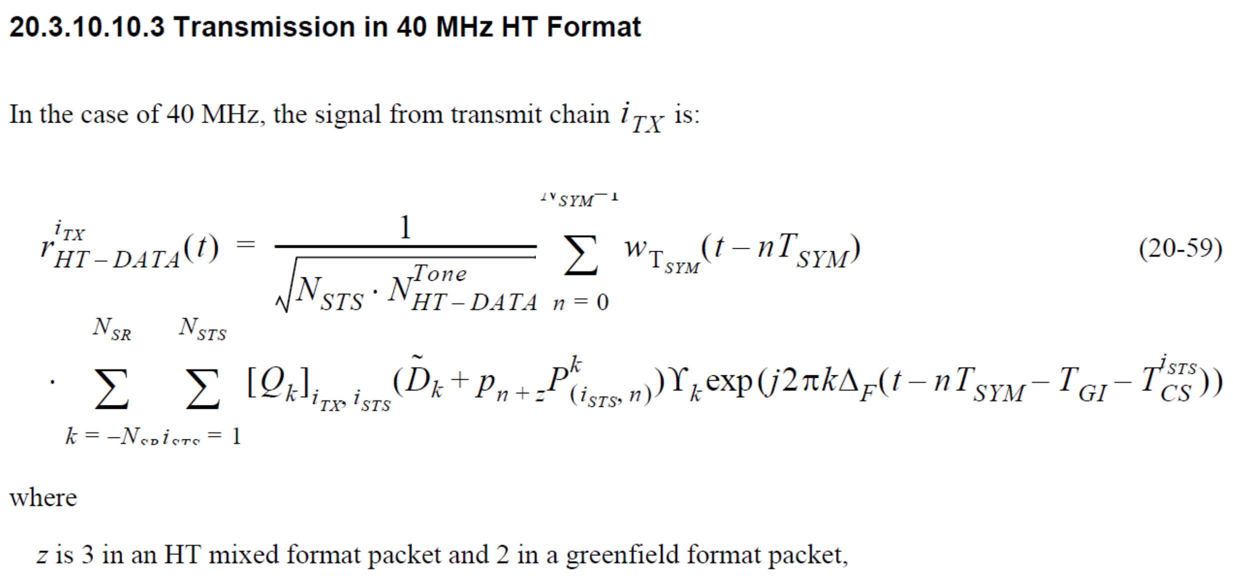
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $$r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS}\cdot N^{Tone}_{HT-DATA}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX},i_{STS}} (\tilde{D}_k + p_{n+z}P^k_{(i_{STS},n)}) \Upsilon_k \exp(j2\pi k\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{STS}}_{CS}))$$ (20-59) where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

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	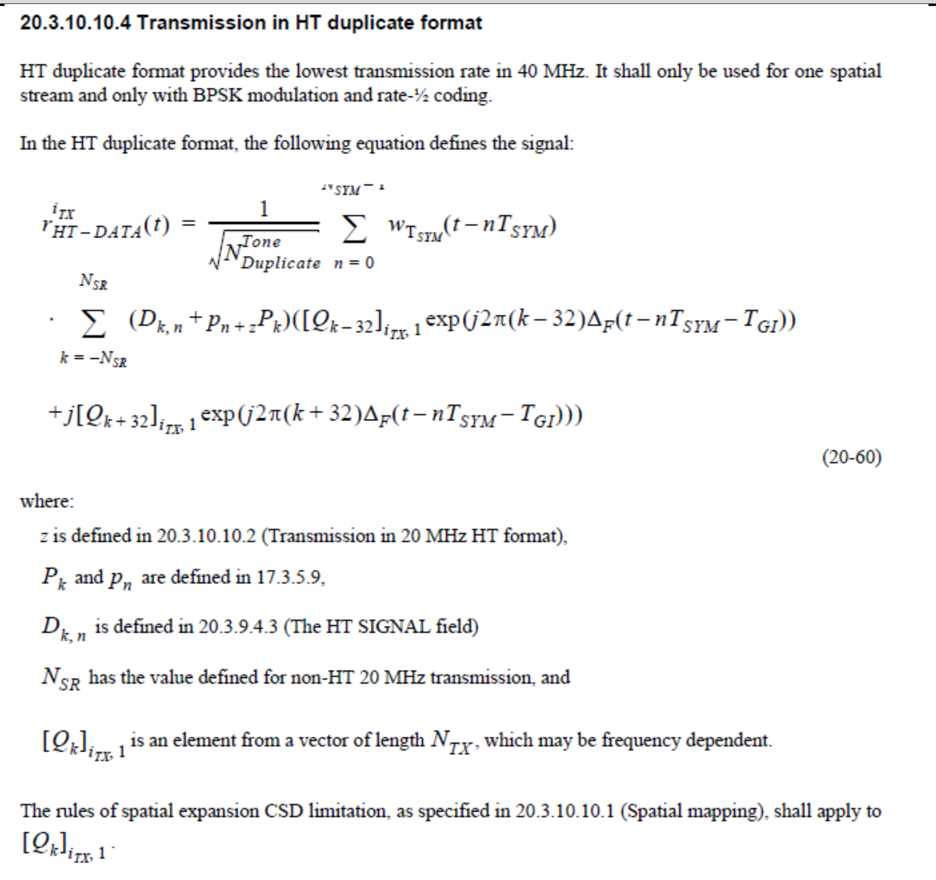 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n}+p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI})) + j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

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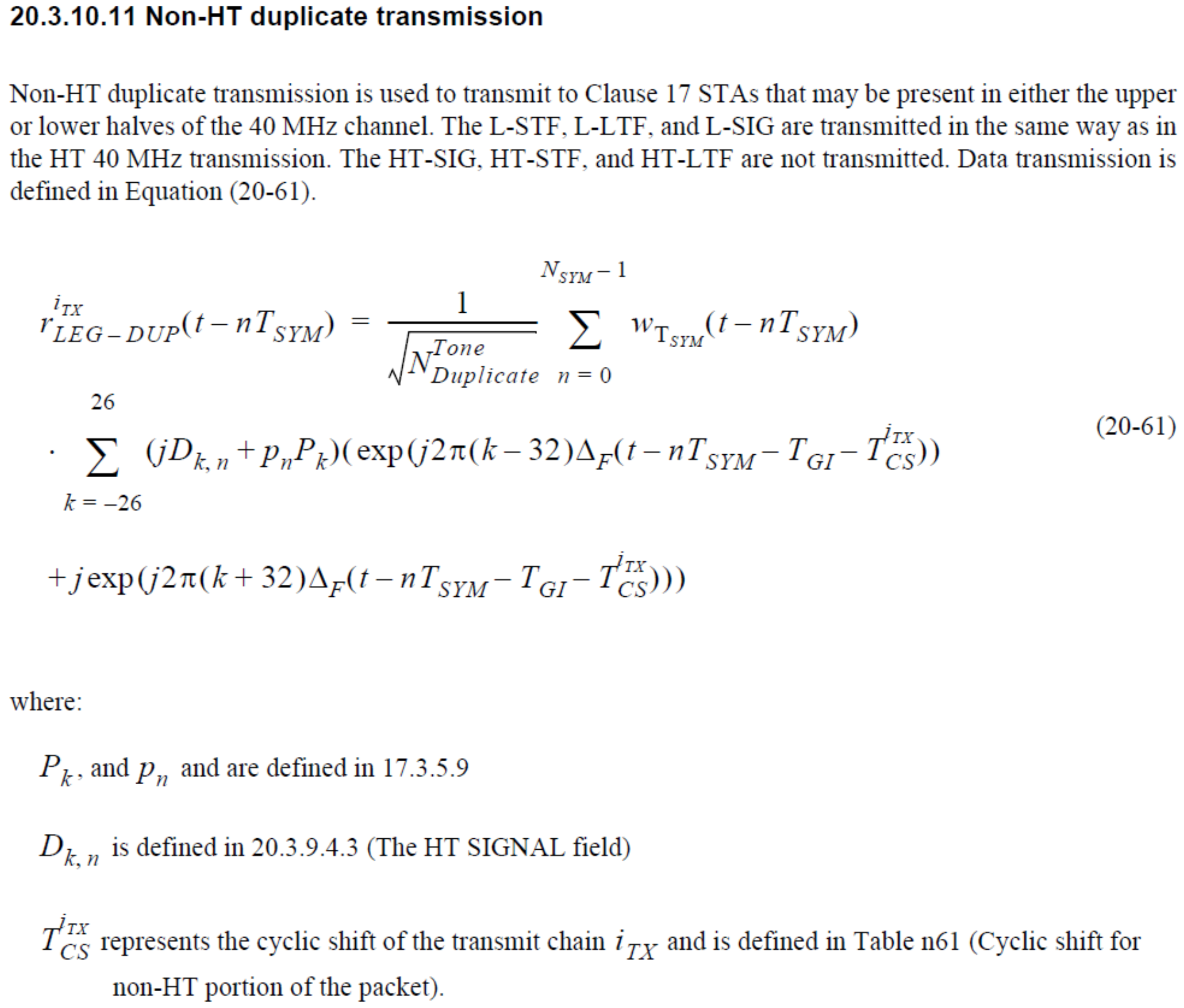
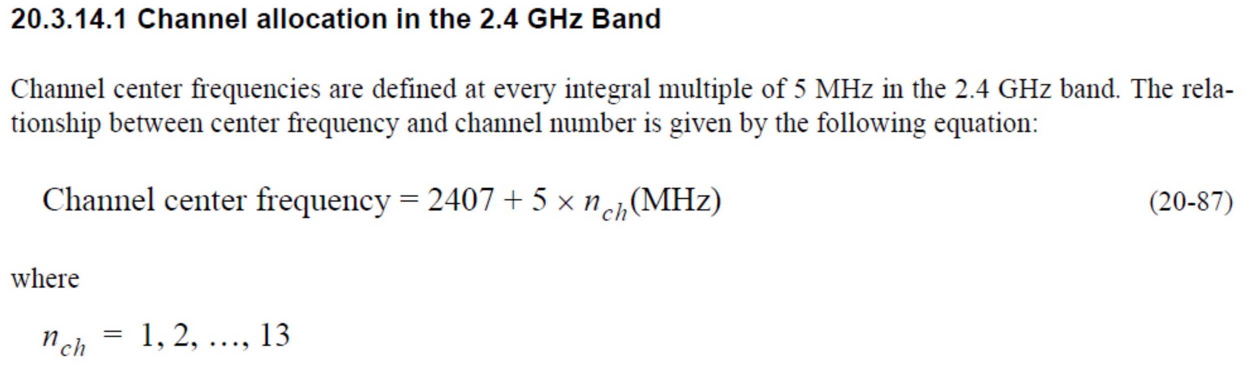
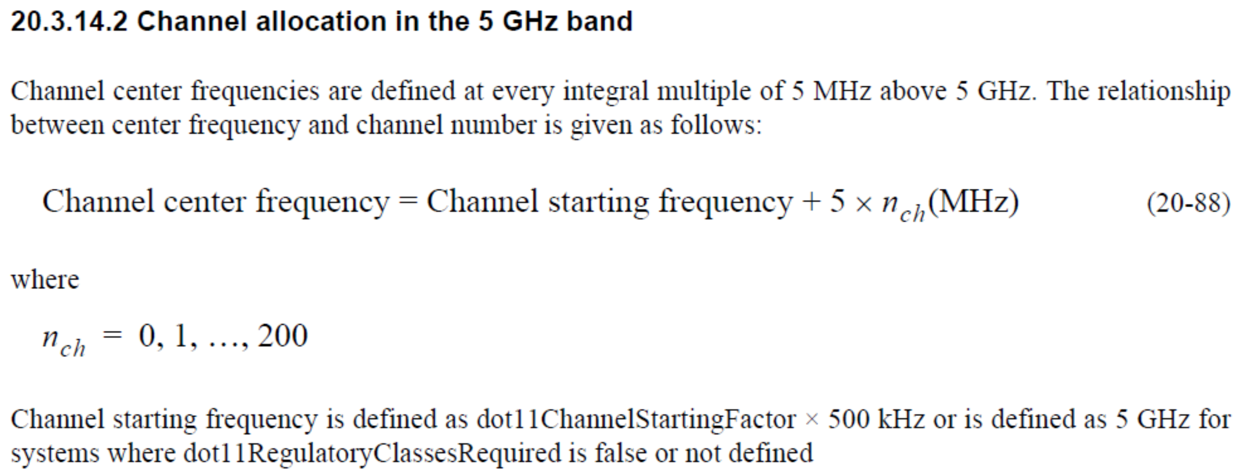
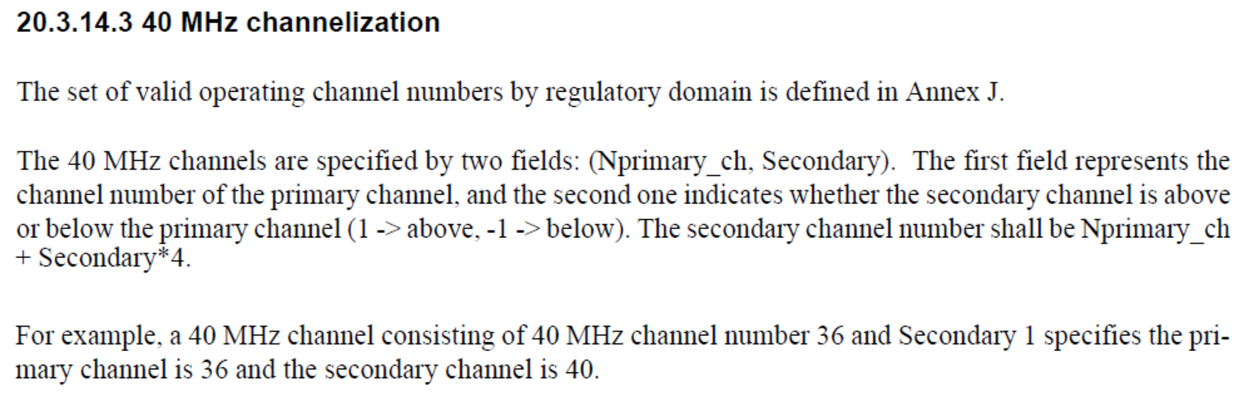
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r^{i_{TX}}_{LEG-DUP}(t - nT_{SYM}) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n} + p_n P_k)(\exp(j2\pi(k-32)\Delta_F(t - nT_{SYM} - T_{GI} - T^{i_{TX}}_{CS})) + j\exp(j2\pi(k+32)\Delta_F(t - nT_{SYM} - T_{GI} - T^{i_{TX}}_{CS})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T^{i_{TX}}_{CS}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz})$ (20-87) where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz})$ (20-88) where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

<table>
<tr><th>Claim 10 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>See, e.g., 802.11n D2.0 § 20.3.20.3

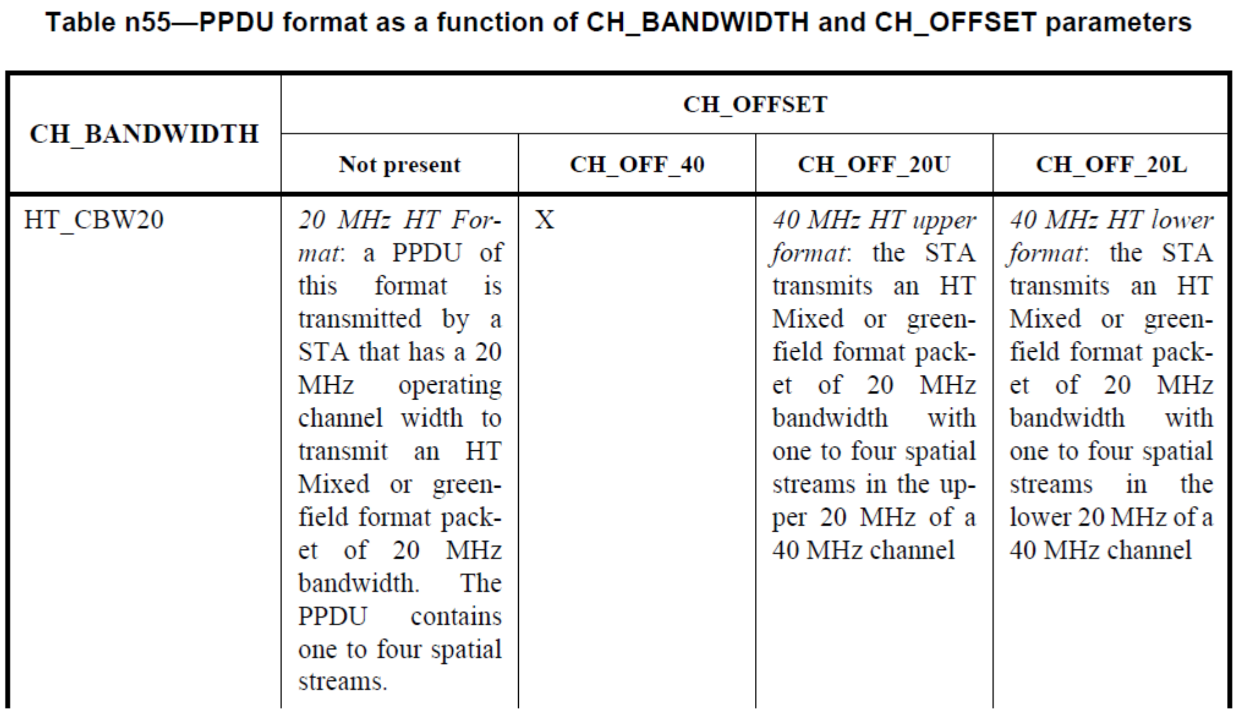
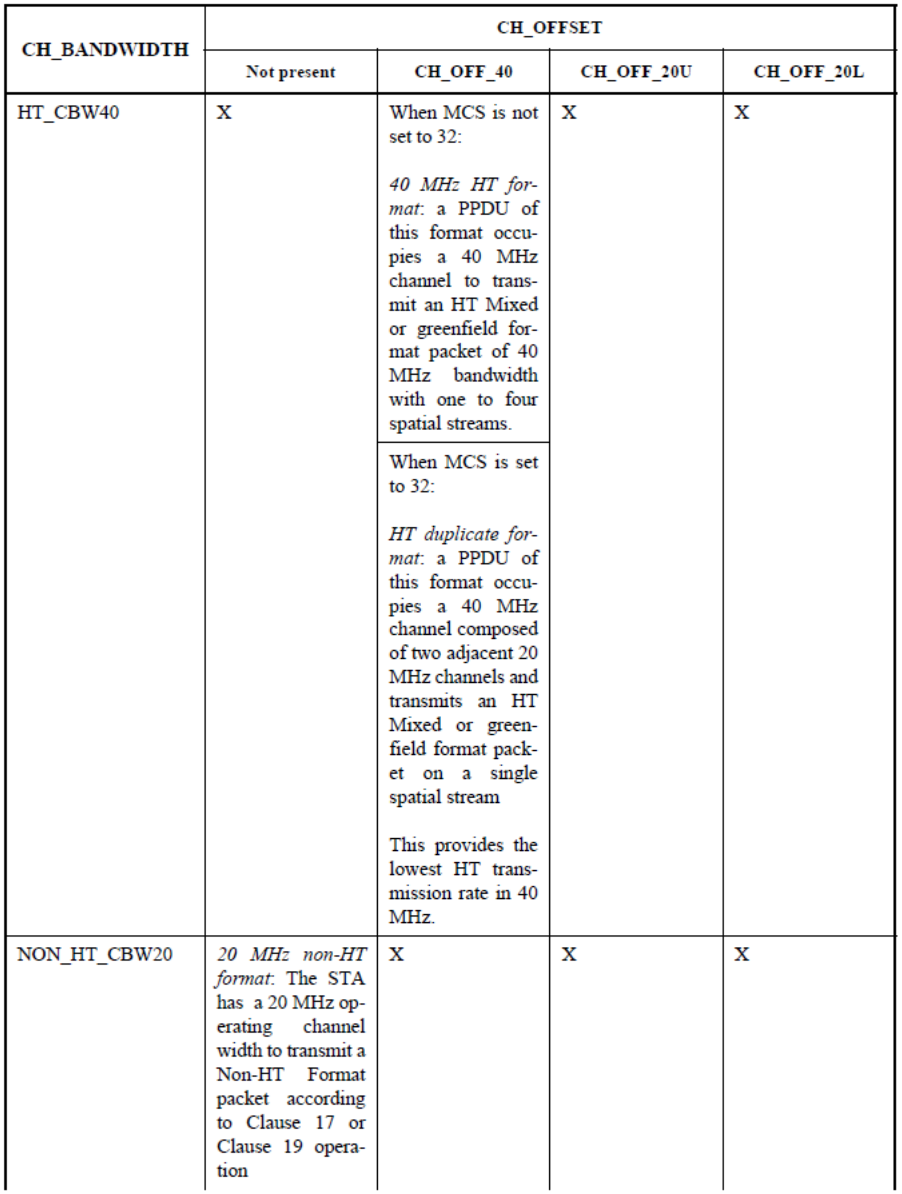
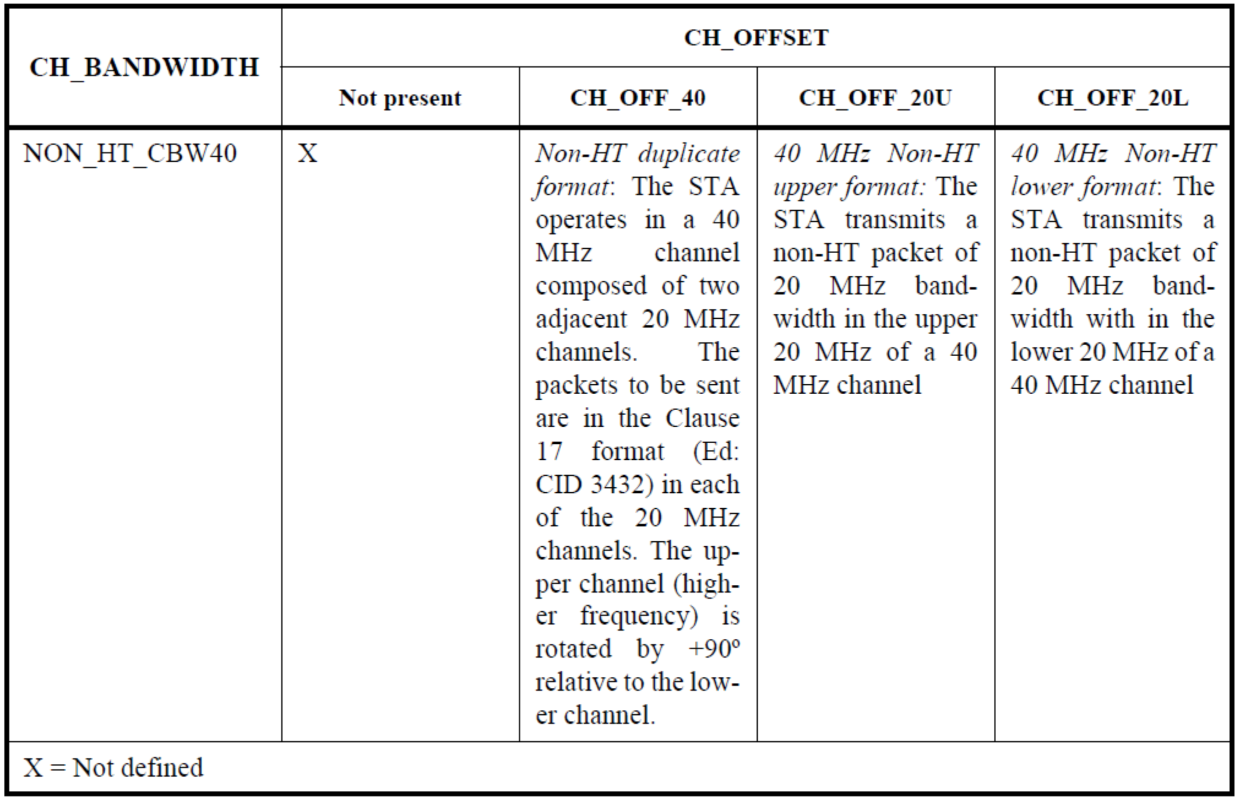


Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>HT_CBW20</td><td><i>20 MHz HT Format</i>: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.</td><td>X</td><td><i>40 MHz HT upper format</i>: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel</td><td><i>40 MHz HT lower format</i>: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel</td></tr>
</table>
</td></tr>
</table>



CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

<table>
<tr><th>Claim 10 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>NON_HT_CBW40</td><td>X</td><td>*Non-HT duplicate format*: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.</td><td>*40 MHz Non-HT upper format:* The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel</td><td>*40 MHz Non-HT lower format*: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel</td></tr>
<tr><td colspan="5">X = Not defined</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n55
</td></tr>
</table>

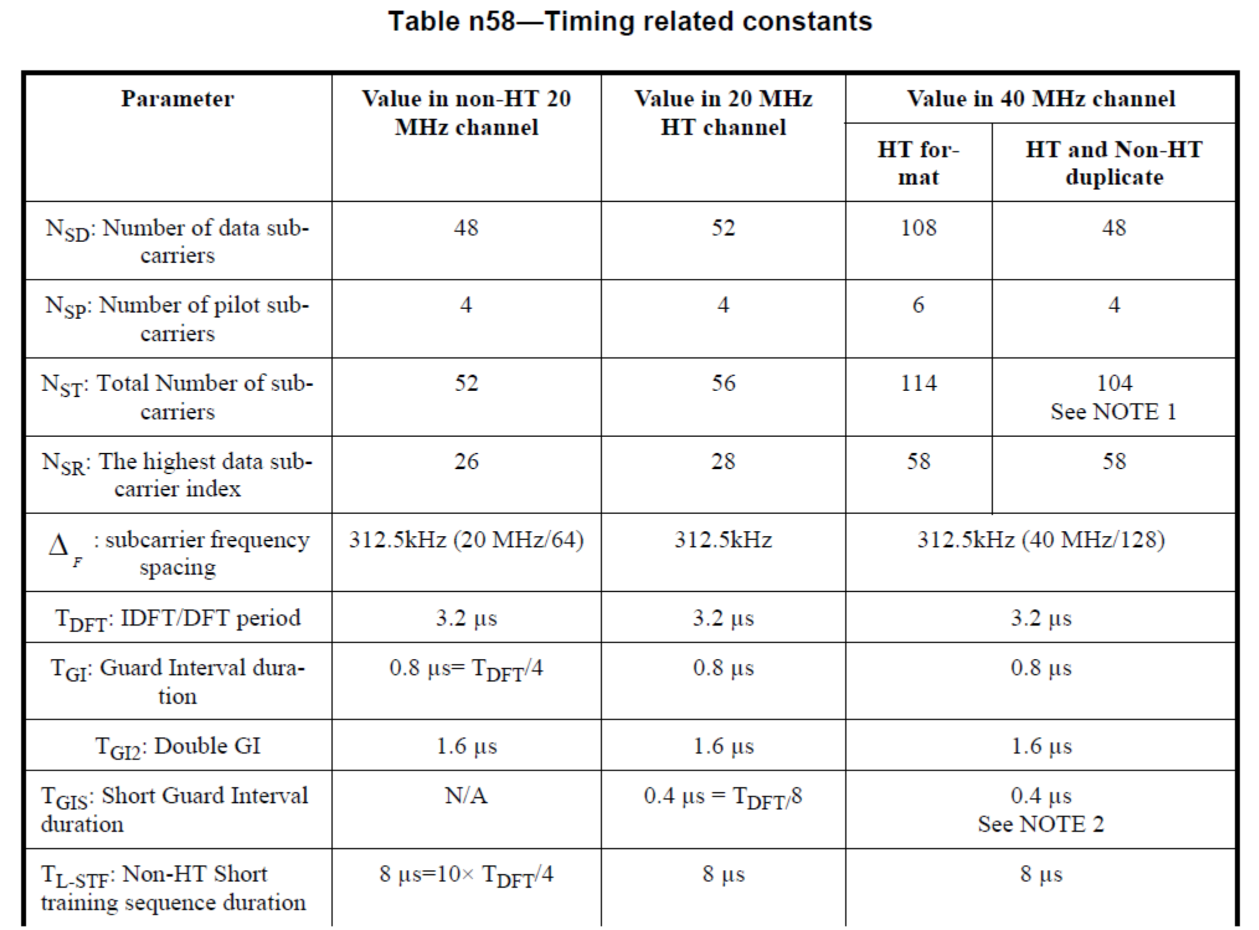
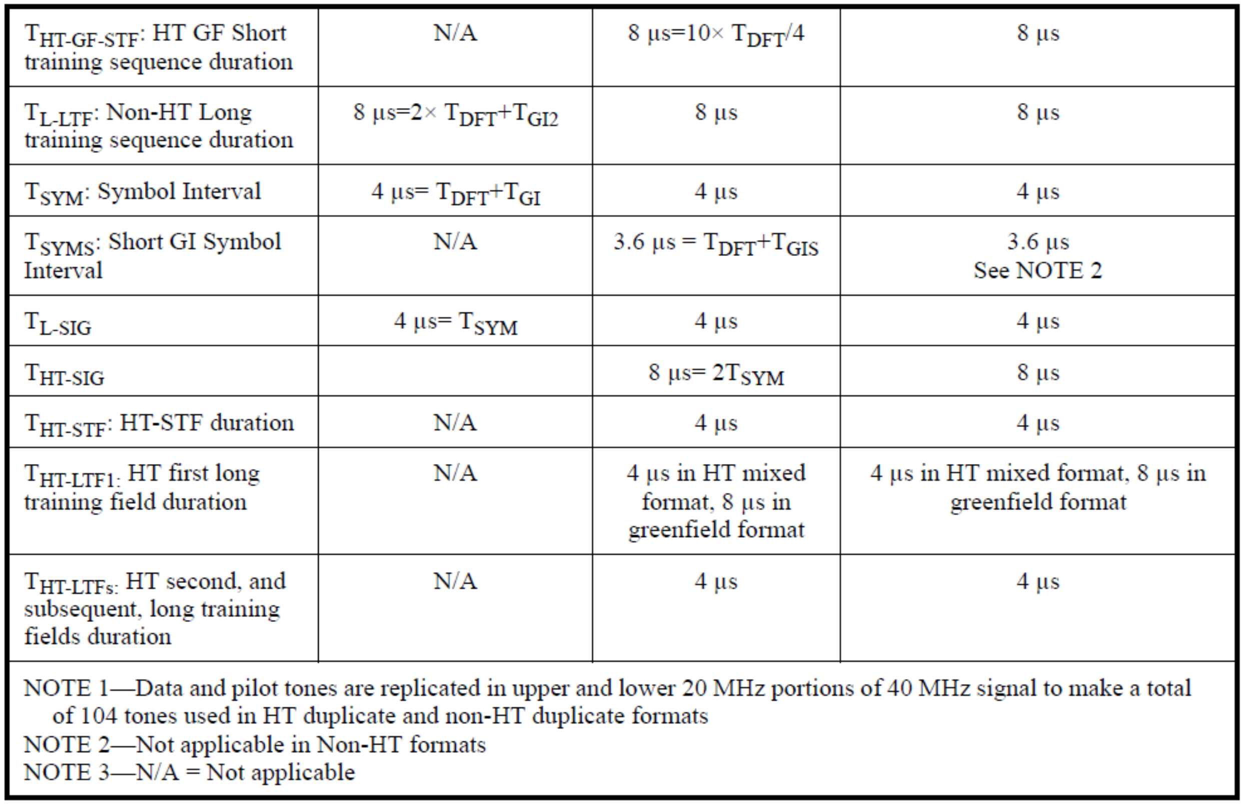
Claim 10 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	

Table n58—Timing related constants

Parameter	**Value in non-HT 20 MHz channel**	**Value in 20 MHz HT channel**	**Value in 40 MHz channel**	
			HT format	**HT and Non-HT duplicate**
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

Claim 10 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	See table below



$T_{\text{HT-GF-STF}}$: HT GF Short training sequence duration	N/A	8 μs=10× T_{DFT}/4	8 μs
$T_{\text{L-LTF}}$: Non-HT Long training sequence duration	8 μs=2× T_{DFT}+T_{GI2}	8 μs	8 μs
T_{SYM}: Symbol Interval	4 μs= T_{DFT}+T_{GI}	4 μs	4 μs
T_{SYMS}: Short GI Symbol Interval	N/A	3.6 μs = T_{DFT}+T_{GIS}	3.6 μs See NOTE 2
$T_{\text{L-SIG}}$	4 μs= T_{SYM}	4 μs	4 μs
$T_{\text{HT-SIG}}$		8 μs= 2T_{SYM}	8 μs
$T_{\text{HT-STF}}$: HT-STF duration	N/A	4 μs	4 μs
$T_{\text{HT-LTF1}}$: HT first long training field duration	N/A	4 μs in HT mixed format, 8 μs in greenfield format	4 μs in HT mixed format, 8 μs in greenfield format
$T_{\text{HT-LTFs}}$: HT second, and subsequent, long training fields duration	N/A	4 μs	4 μs

NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable

See, e.g., 802.11n D2.0 Table n58

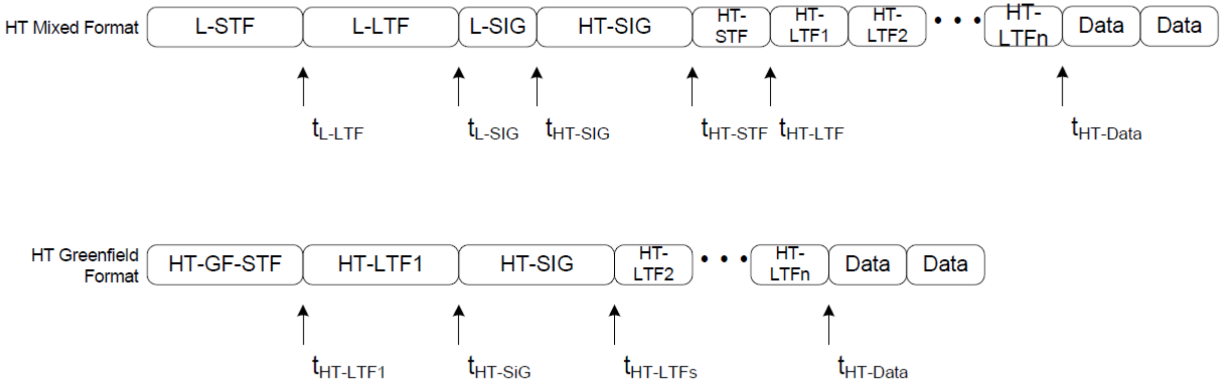
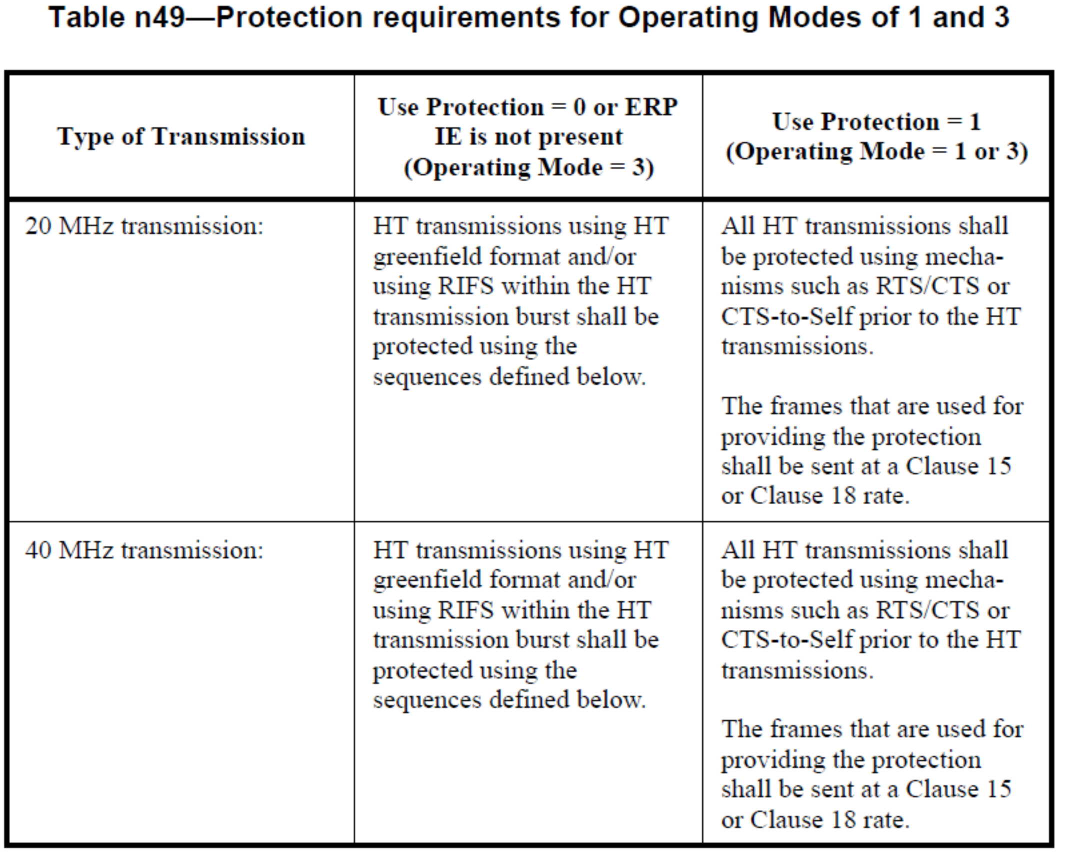
<table>
<tr><th>Claim 10 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>


Figure n65—Timing boundaries for PPDU fields

See, e.g., 802.11n D2.0 Figure n65

Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.
</td></tr>
<tr><td>[10.7] up-converting the second analog signal to a second RF center frequency greater than the first center RF frequency to produce a second up-converted analog signal, wherein the second up-converted analog signal</td><td>802.11n D2.0 discloses “up-converting the second analog signal to a second RF center frequency greater than the first center RF frequency to produce a second up-converted analog signal, wherein the second up-converted analog signal comprises a second up-converted frequency range from the second RF center frequency minus one-half the second frequency range to the second RF center frequency plus one-half the second frequency range, and wherein a frequency difference between the first RF center frequency and the second RF center frequency is greater than the sum of one-half the first frequency range and one-half the second frequency range.” See, e.g.:</td></tr>
</table>

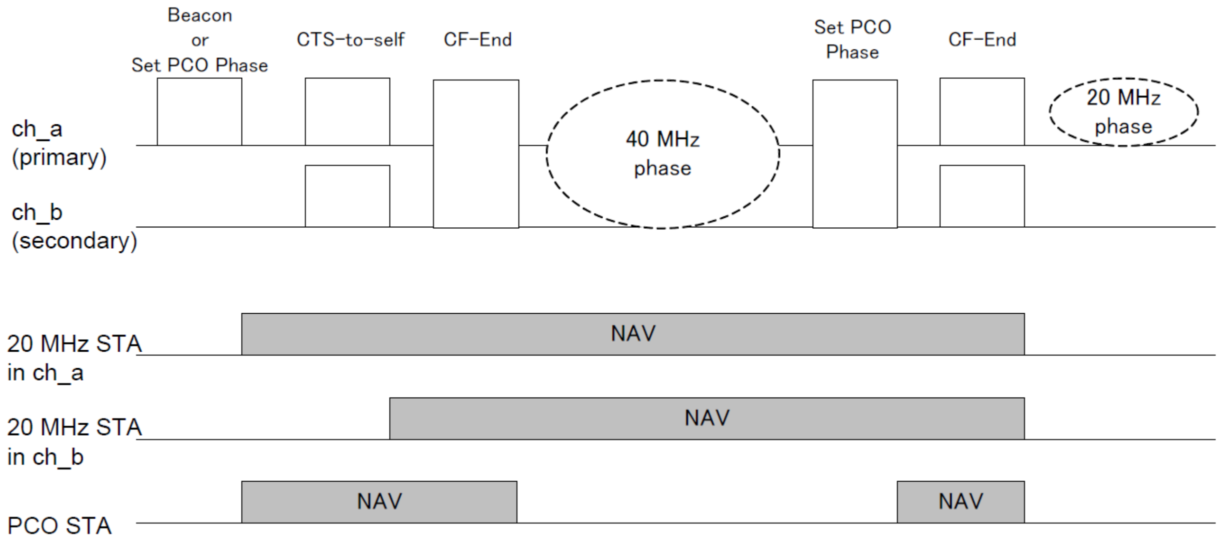
Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
comprises a second up-converted frequency range from the second RF center frequency minus one-half the second frequency range to the second RF center frequency plus one-half the second frequency range, and wherein a frequency difference between the first RF center frequency and the second RF center frequency is greater than the sum of one-half the first frequency range and one-half the second frequency range;	**high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19 **non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 Table n49—Protection requirements for Operating Modes of 1 and 3 If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways: a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions: 1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19 2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20. NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).

Type of Transmission	Use Protection = 0 or ERP IE is not present (Operating Mode = 3)	Use Protection = 1 (Operating Mode = 1 or 3)
20 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.
40 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

<table>
<tr><th>Claim 10 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>



A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU.

During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel.

During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS.

A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS.

The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

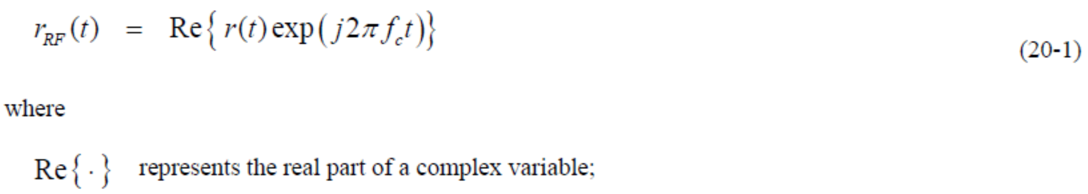
</td></tr>
</table>

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation:  $r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t\right)\right\}$ (20-1) where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

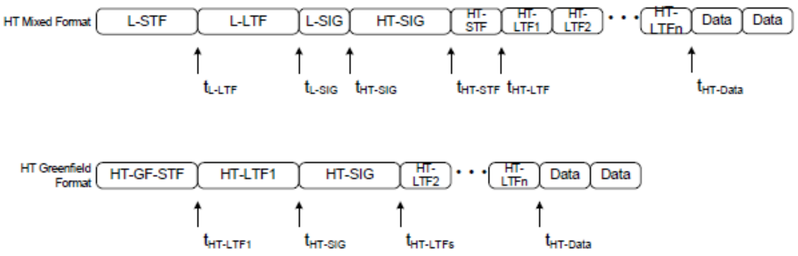


Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) \;=\; & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right)T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \tag{20-2}$$

where

$$t_{L-LTF} = T_{L-STF}$$

$$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$$

$$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$$

$$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$r_{PPDU}^{(i_{TX})}(t) = r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1})$$

$$+ r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG})$$

$$+ \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2) T_{HT-LTFs})$$

$$+ r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \qquad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\text{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\text{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j 2\pi k \Delta_F t) \qquad (20\text{-}4)$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \leq 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \qquad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \qquad (20\text{-}6)$$

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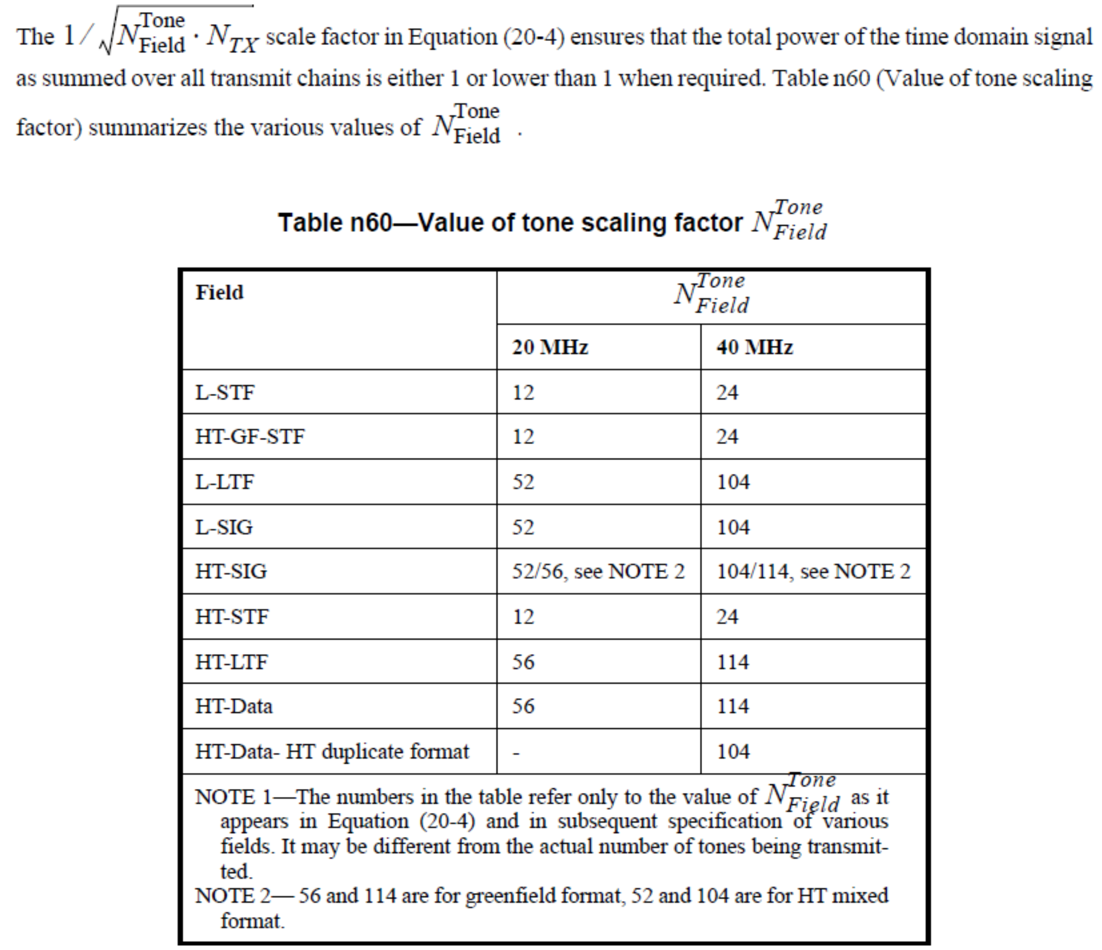

The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	40 MHz
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

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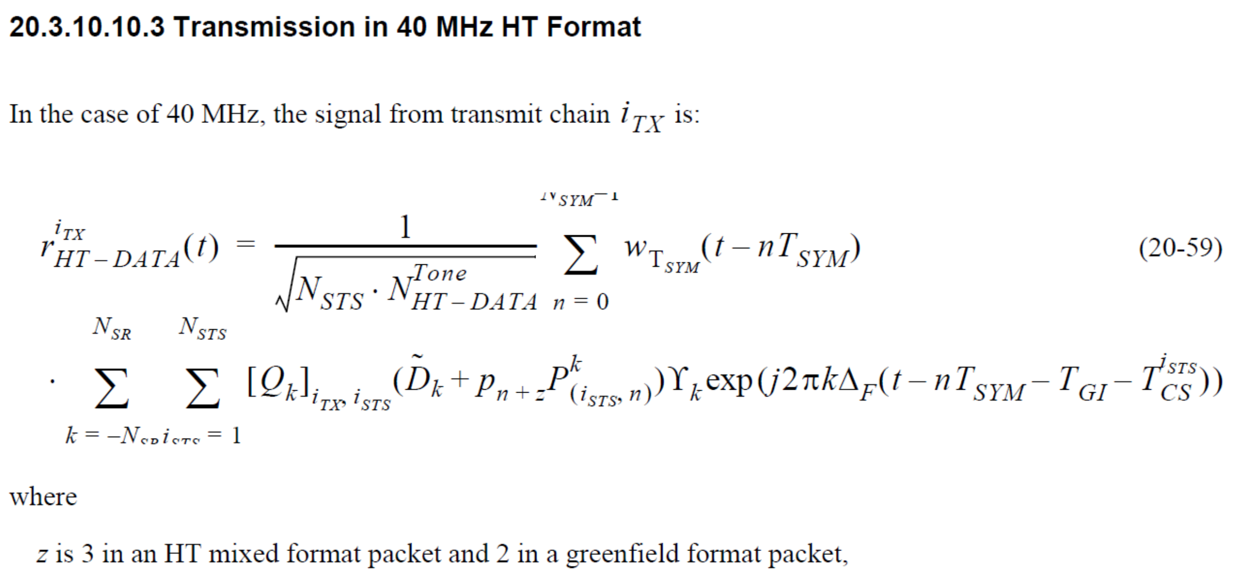
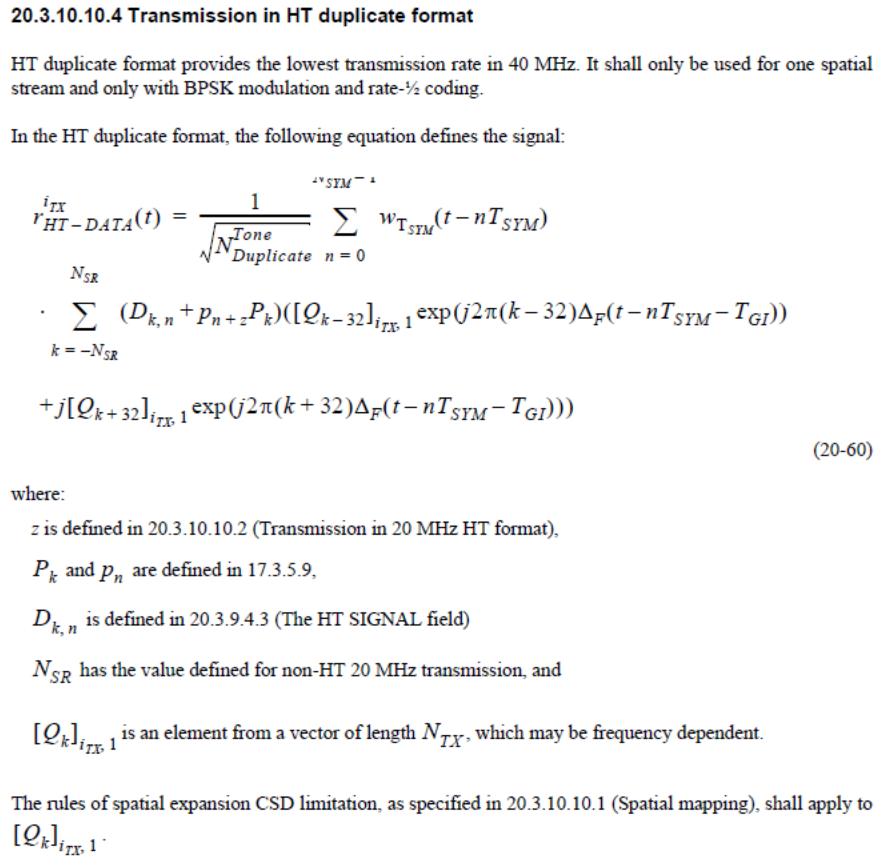
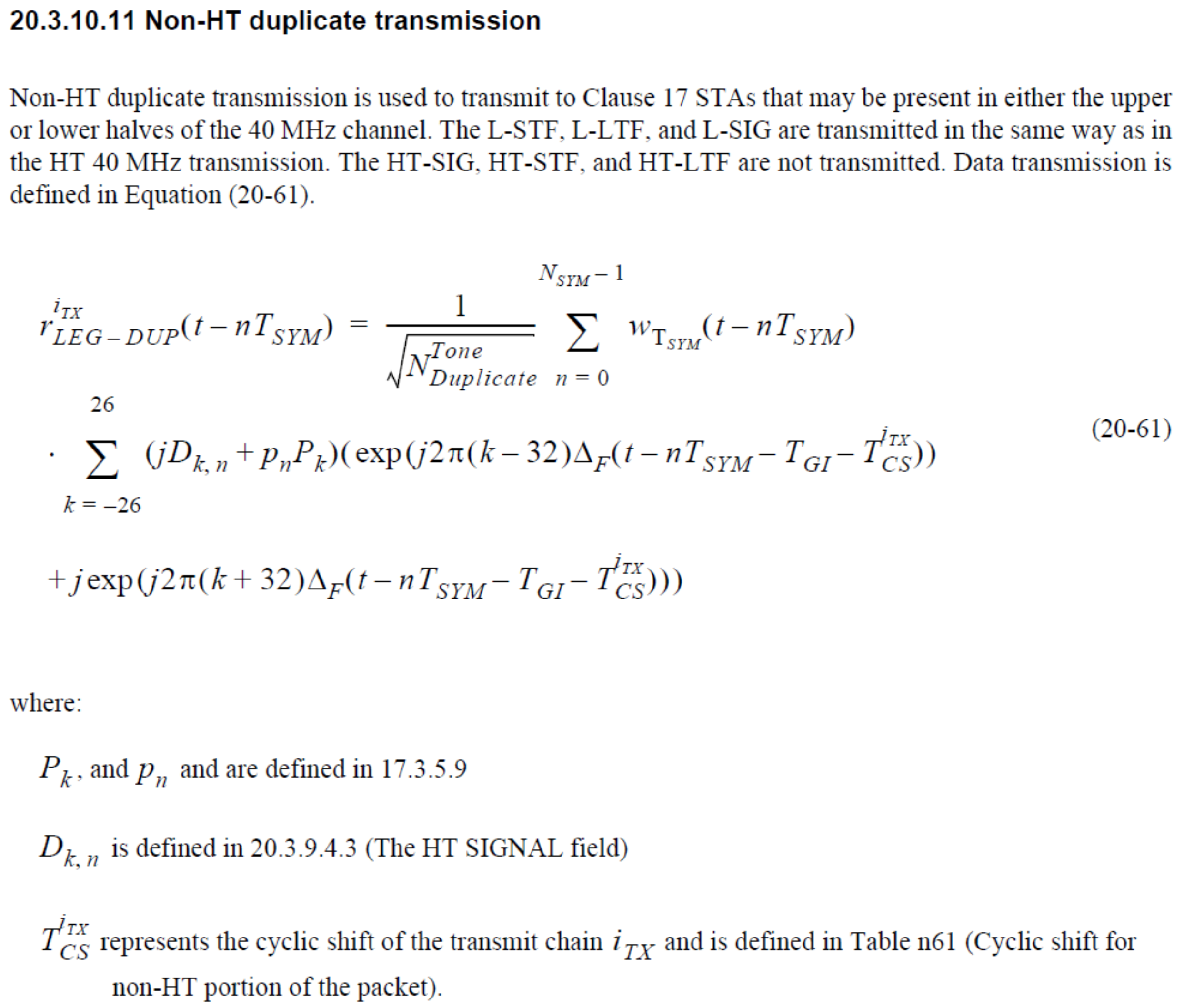
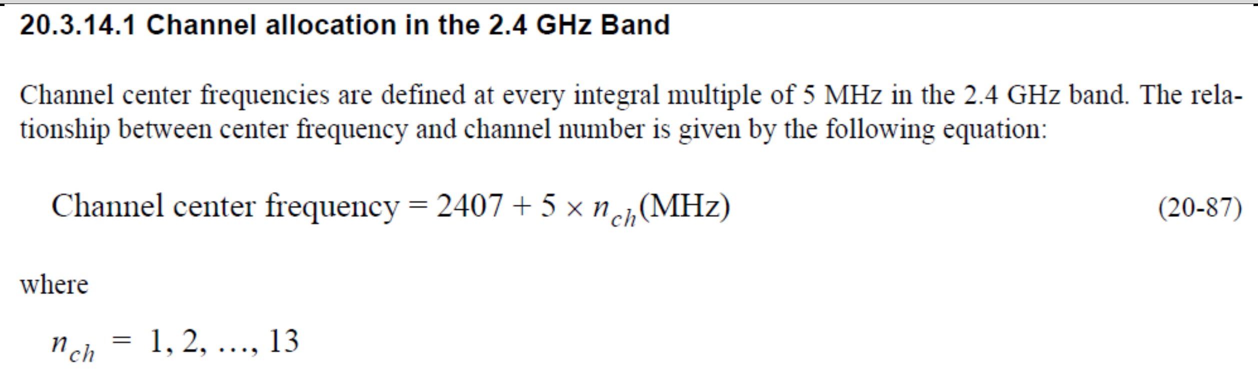
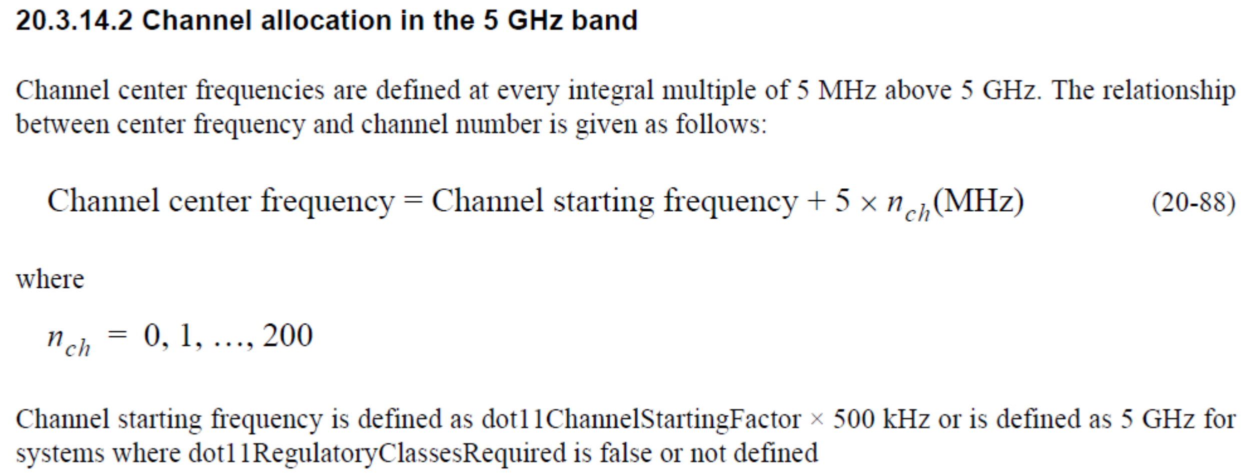
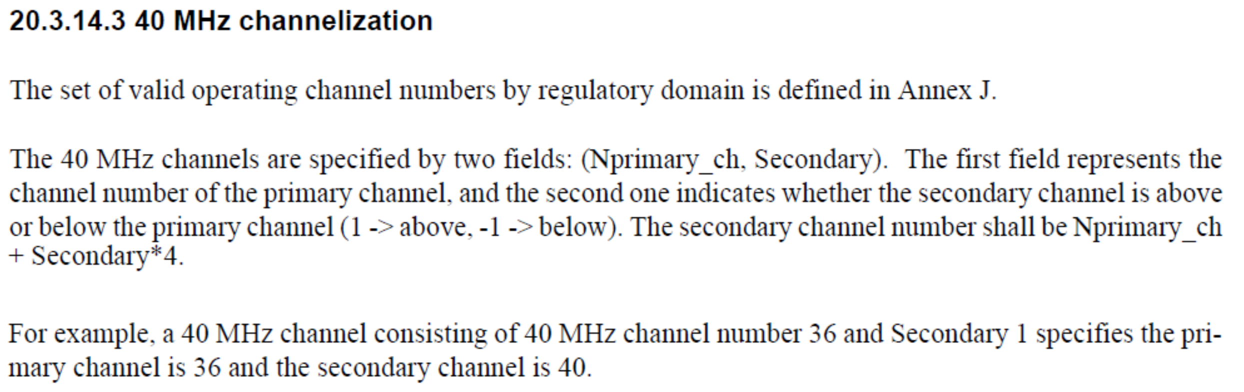
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS} \cdot N^{Tone}_{HT-DATA}}} \sum_{n=0}^{N_{SYM}-1} w_{\mathrm{T}_{SYM}}(t - nT_{SYM})$ (20-58) $\cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P^k_{(i_{STS},n)}) \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T^{i_{STS}}_{CS}))$ where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P^k_{(i_{STS}, n)}) \Upsilon_k \exp(j2\pi k \Delta_F(t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (20-59) where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $$r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n} + p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t - nT_{SYM} - T_{GI})) + j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t - nT_{SYM} - T_{GI})))$$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

Claim 10 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r^{i_{TX}}_{LEG-DUP}(t - nT_{SYM}) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n} + p_n P_k)(\exp(j2\pi(k-32)\Delta_F(t - nT_{SYM} - T_{GI} - T^{i_{TX}}_{CS})) + j\exp(j2\pi(k+32)\Delta_F(t - nT_{SYM} - T_{GI} - T^{i_{TX}}_{CS})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T^{i_{TX}}_{CS}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz}) \qquad (20\text{-}87)$ where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz}) \qquad (20\text{-}88)$ where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

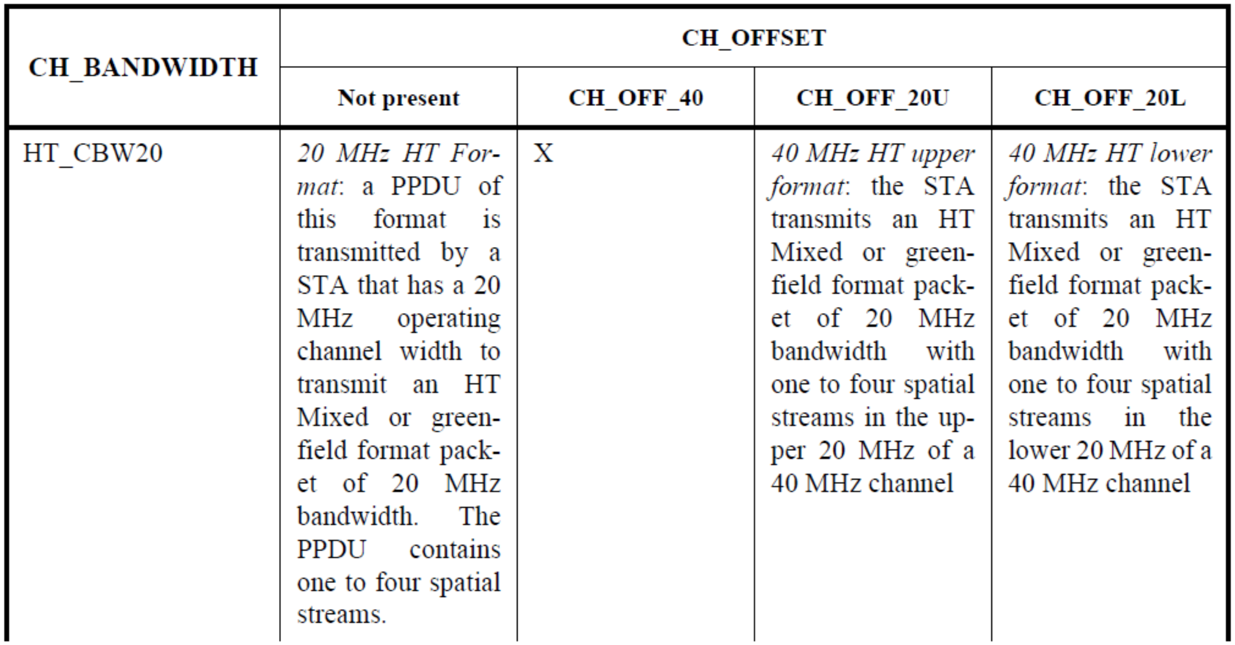
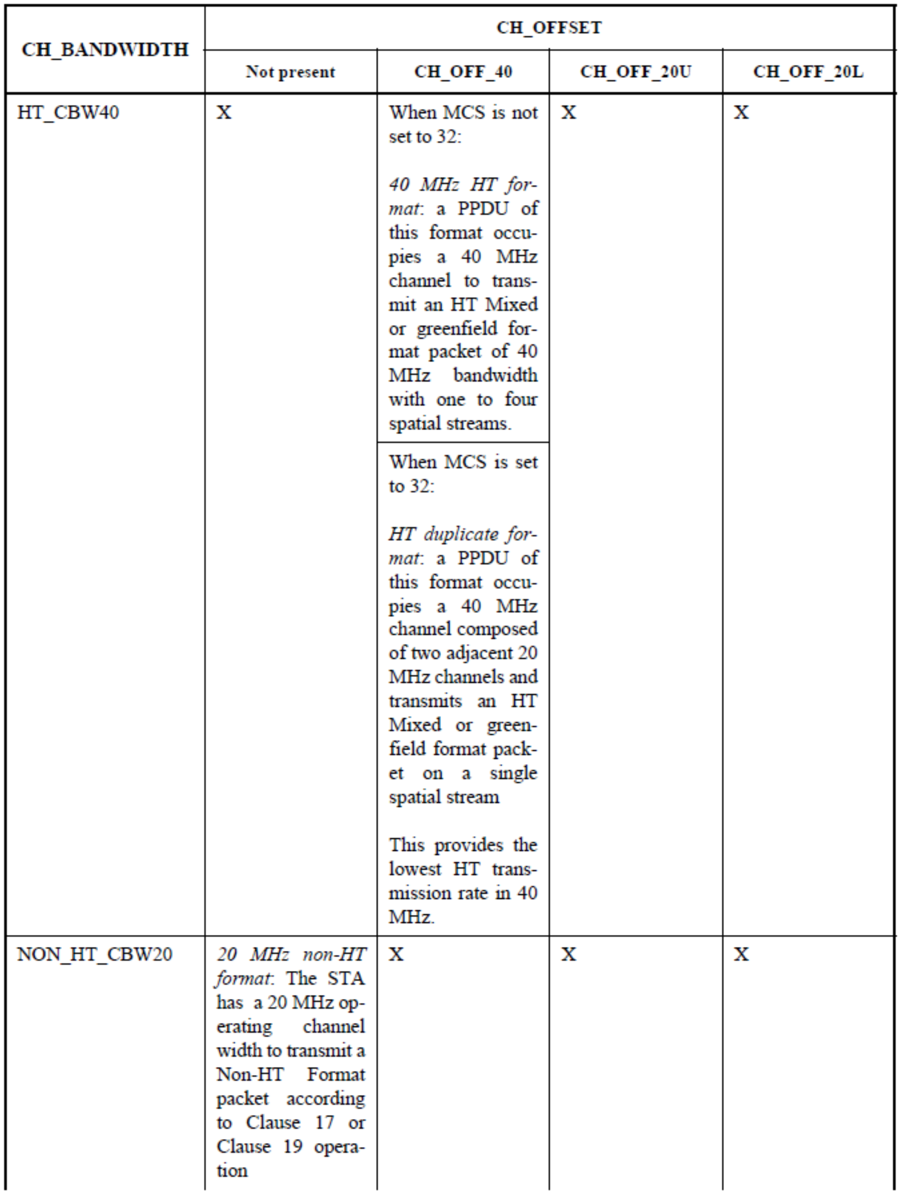
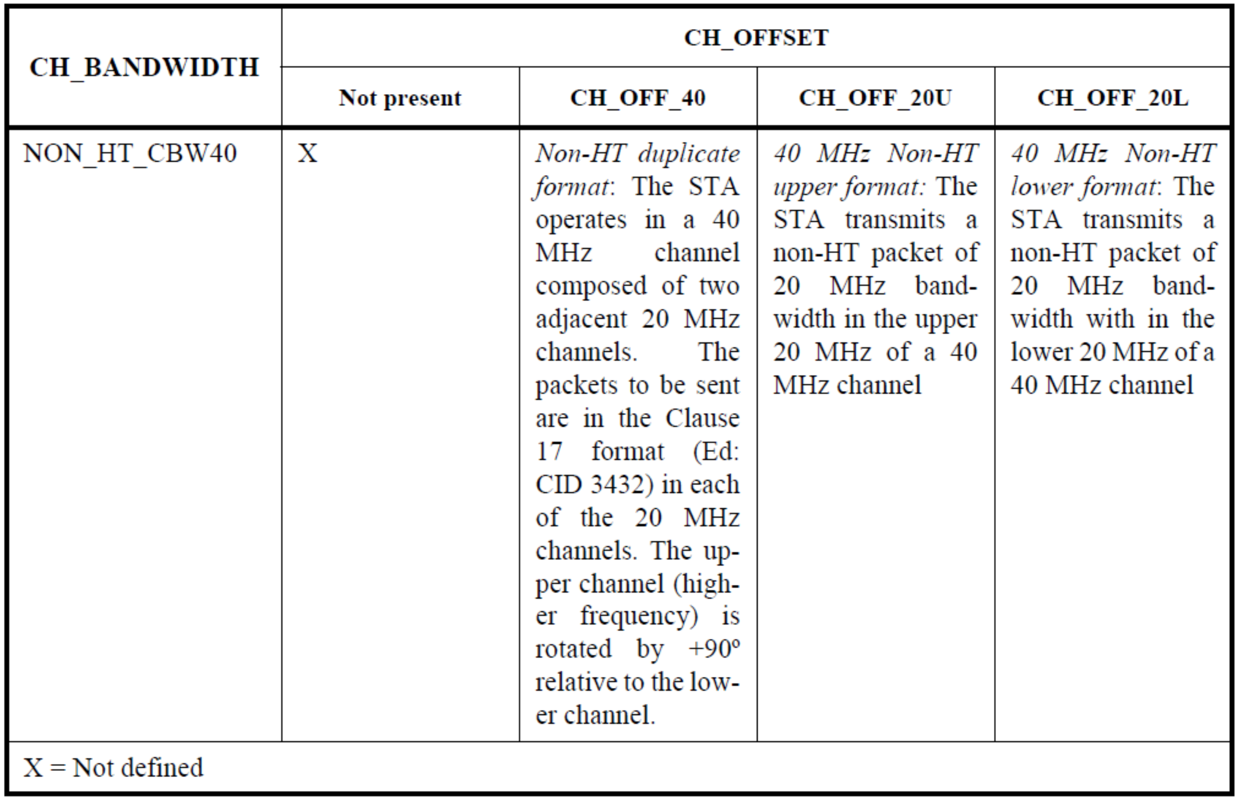
Claim 10 of the '802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.20.3 

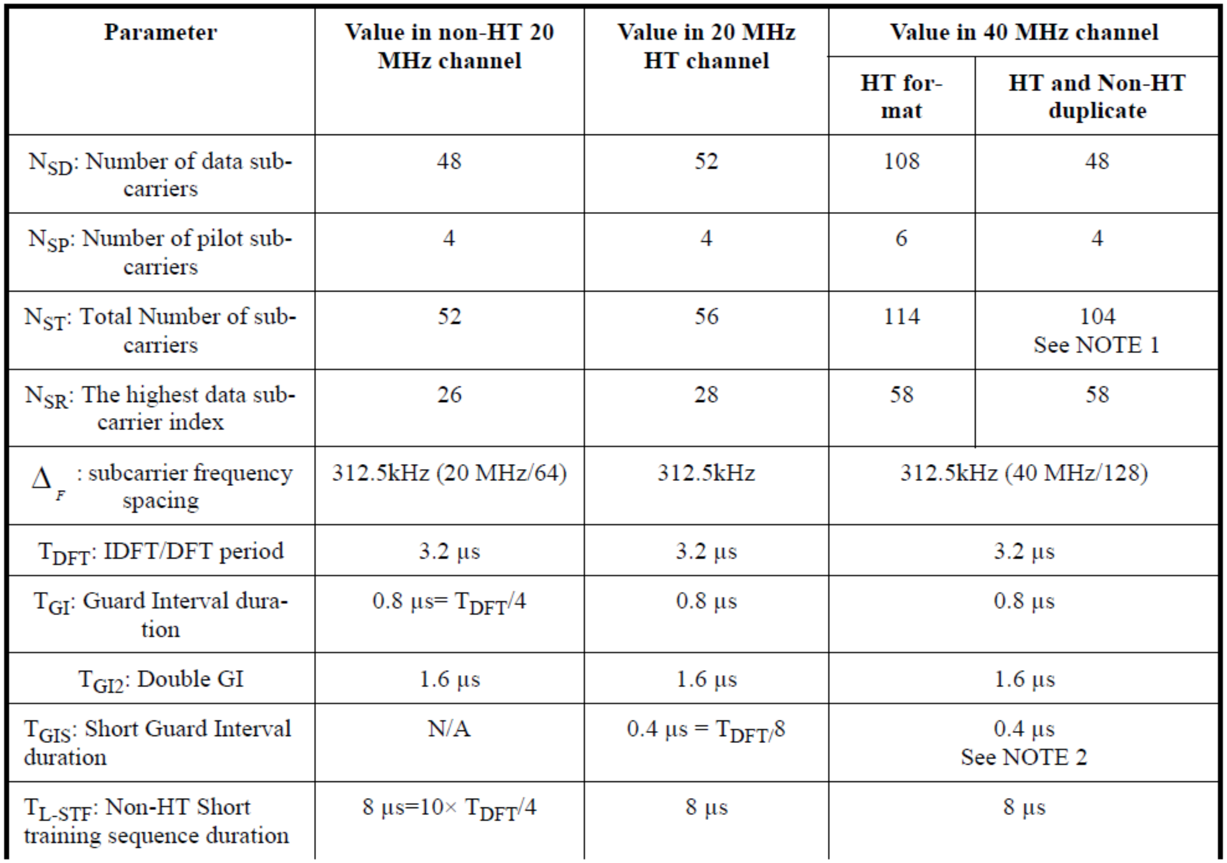
Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel

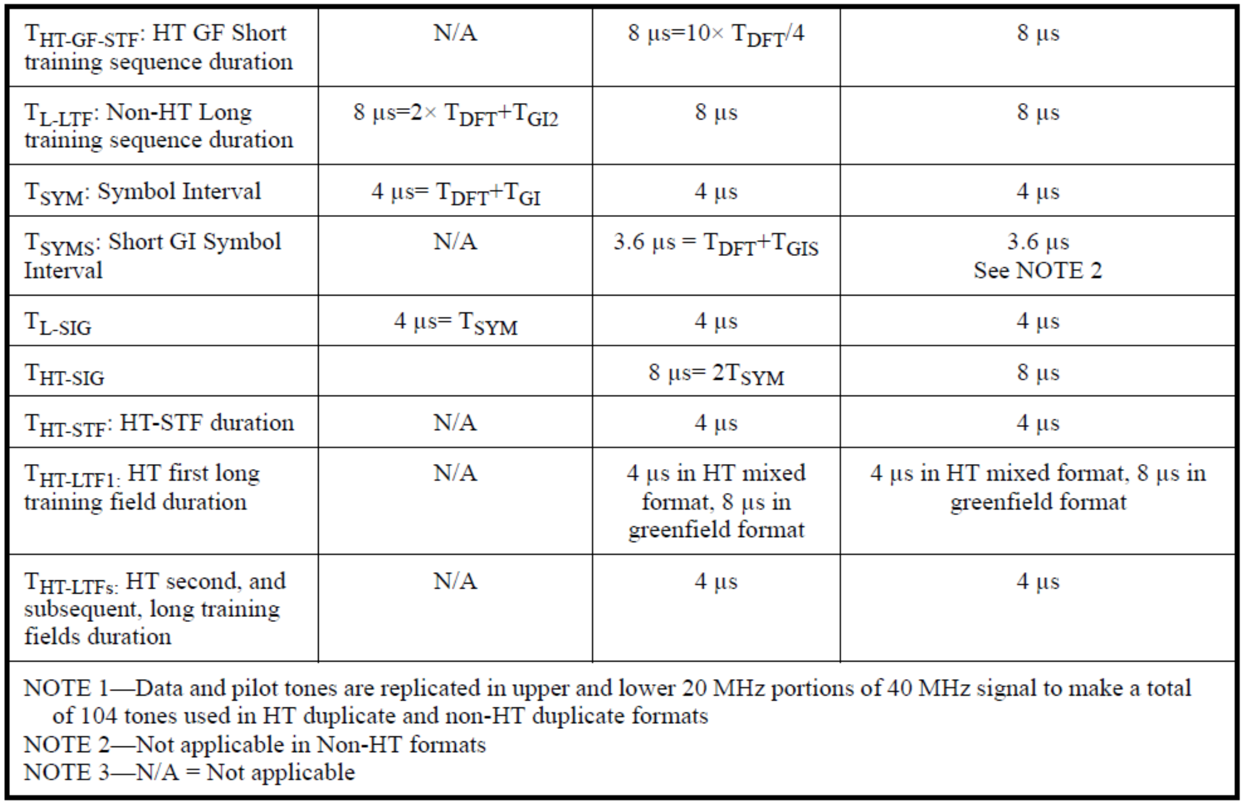


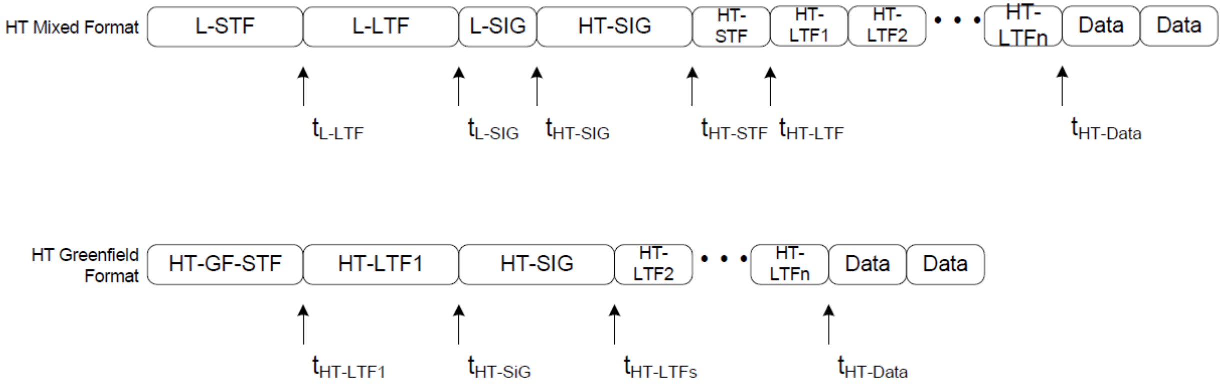
CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams.	X	X
		When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.		
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

<table>
<tr><th>Claim 10 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>NON_HT_CBW40</td><td>X</td><td><i>Non-HT duplicate format</i>: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.</td><td><i>40 MHz Non-HT upper format:</i> The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel</td><td><i>40 MHz Non-HT lower format</i>: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel</td></tr>
<tr><td colspan="5">X = Not defined</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n55
</td></tr>
</table>

Claim 10 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	Table n58—Timing related constants 

Parameter	**Value in non-HT 20 MHz channel**	**Value in 20 MHz HT channel**	**Value in 40 MHz channel**	
			HT format	**HT and Non-HT duplicate**
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

<table>
<tr><th>Claim 10 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><td>$T_{\text{HT-GF-STF}}$: HT GF Short training sequence duration</td><td>N/A</td><td>8 μs=10× T_{DFT}/4</td><td>8 μs</td></tr>
<tr><td>$T_{\text{L-LTF}}$: Non-HT Long training sequence duration</td><td>8 μs=2× T_{DFT}+T_{GI2}</td><td>8 μs</td><td>8 μs</td></tr>
<tr><td>T_{SYM}: Symbol Interval</td><td>4 μs= T_{DFT}+T_{GI}</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td>T_{SYMS}: Short GI Symbol Interval</td><td>N/A</td><td>3.6 μs = T_{DFT}+T_{GIS}</td><td>3.6 μs
See NOTE 2</td></tr>
<tr><td>$T_{\text{L-SIG}}$</td><td>4 μs= T_{SYM}</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td>$T_{\text{HT-SIG}}$</td><td></td><td>8 μs= 2T_{SYM}</td><td>8 μs</td></tr>
<tr><td>$T_{\text{HT-STF}}$: HT-STF duration</td><td>N/A</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td>$T_{\text{HT-LTF1:}}$ HT first long training field duration</td><td>N/A</td><td>4 μs in HT mixed format, 8 μs in greenfield format</td><td>4 μs in HT mixed format, 8 μs in greenfield format</td></tr>
<tr><td>$T_{\text{HT-LTFs:}}$ HT second, and subsequent, long training fields duration</td><td>N/A</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td colspan="4">NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n58
</td></tr>
</table>

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.
[10.8] combining the first up-converted analog signal and the second up-converted analog signal to produce a combined up-converted signal;	802.11n D2.0 discloses “combining the first up-converted analog signal and the second up-converted analog signal to produce a combined up-converted signal.” See, e.g.: **high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19 **non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission.

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0

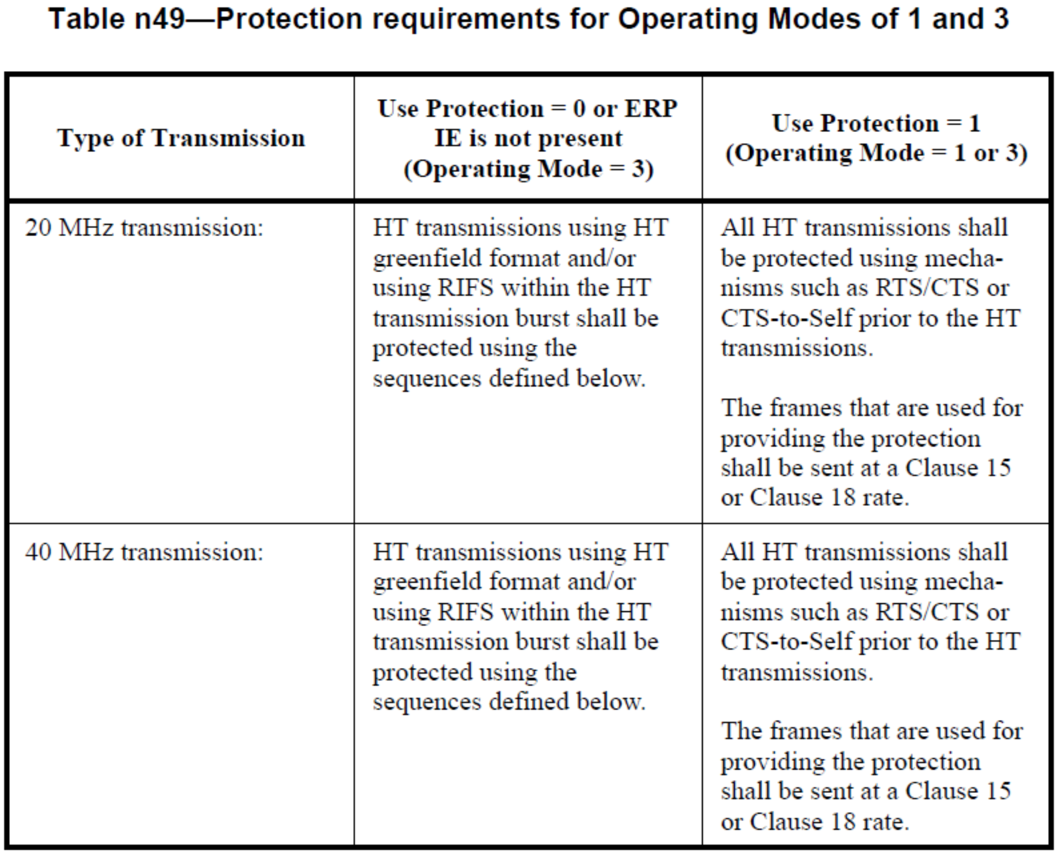
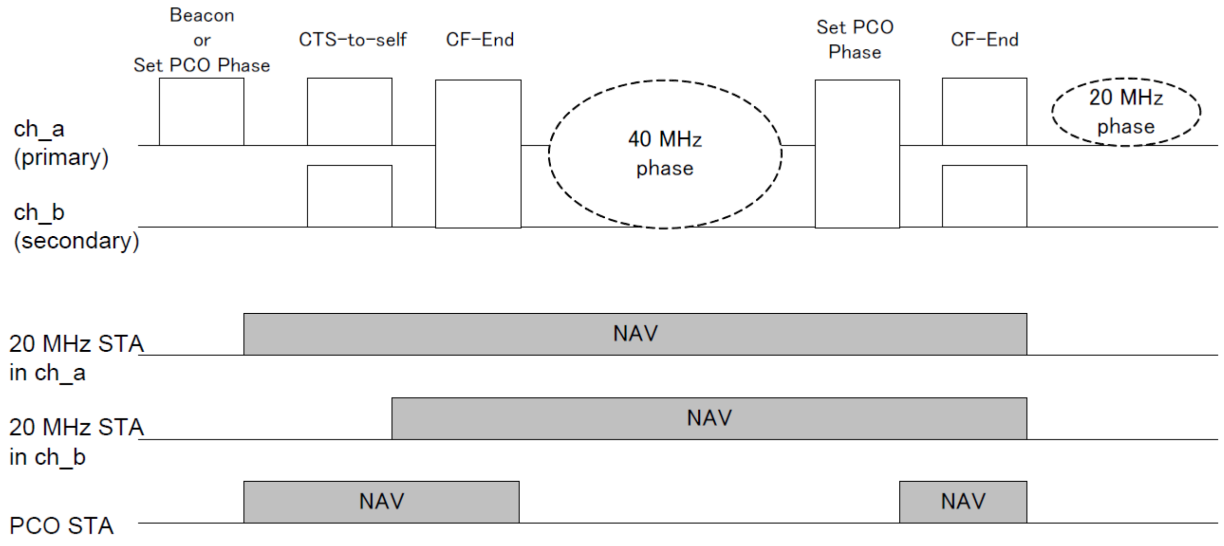


Table n49—Protection requirements for Operating Modes of 1 and 3

Type of Transmission	Use Protection = 0 or ERP IE is not present (Operating Mode = 3)	Use Protection = 1 (Operating Mode = 1 or 3)
20 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.
40 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.
NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

Claim 10 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t\right)\right\}$ (20-1) where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

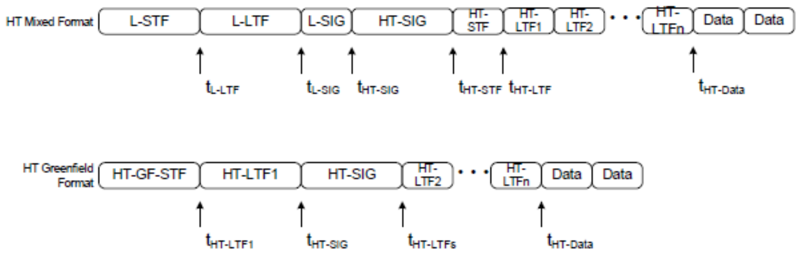


Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field}, determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned}
r_{PPDU}^{(i_{TX})}(t) = \; & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\
& + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\
& + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\
& + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\
& + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right) T_{HT-LTFs}\right) \\
& + r_{HT-DATA}^{(i_{TX})}\left(t - t_{HT-DATA}\right)
\end{aligned} \qquad (20\text{-}2)$$

where

$$t_{L-LTF} = T_{L-STF}$$

$$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$$

$$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$$

$$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r^{(i_{TX})}_{PPDU}(t) = {} & r^{(i_{TX})}_{HT-GF-STF}(t) + r^{(i_{TX})}_{HT-LTF1}(t - t_{HT-LTF1}) \\ & + r^{(i_{TX})}_{HT-SIG}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r^{(i_{TX}, i_{LTF})}_{HT-LTF}(t - t_{HT-LTFs} - (i_{LTF} - 2) T_{HT-LTFs}) \\ & + r^{(i_{TX})}_{HT-DATA}(t - t_{HT-DATA}) \end{aligned} \qquad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r^{(i_{TX})}_{\text{Field}}(t)$, is defined via the discrete Fourier transform as

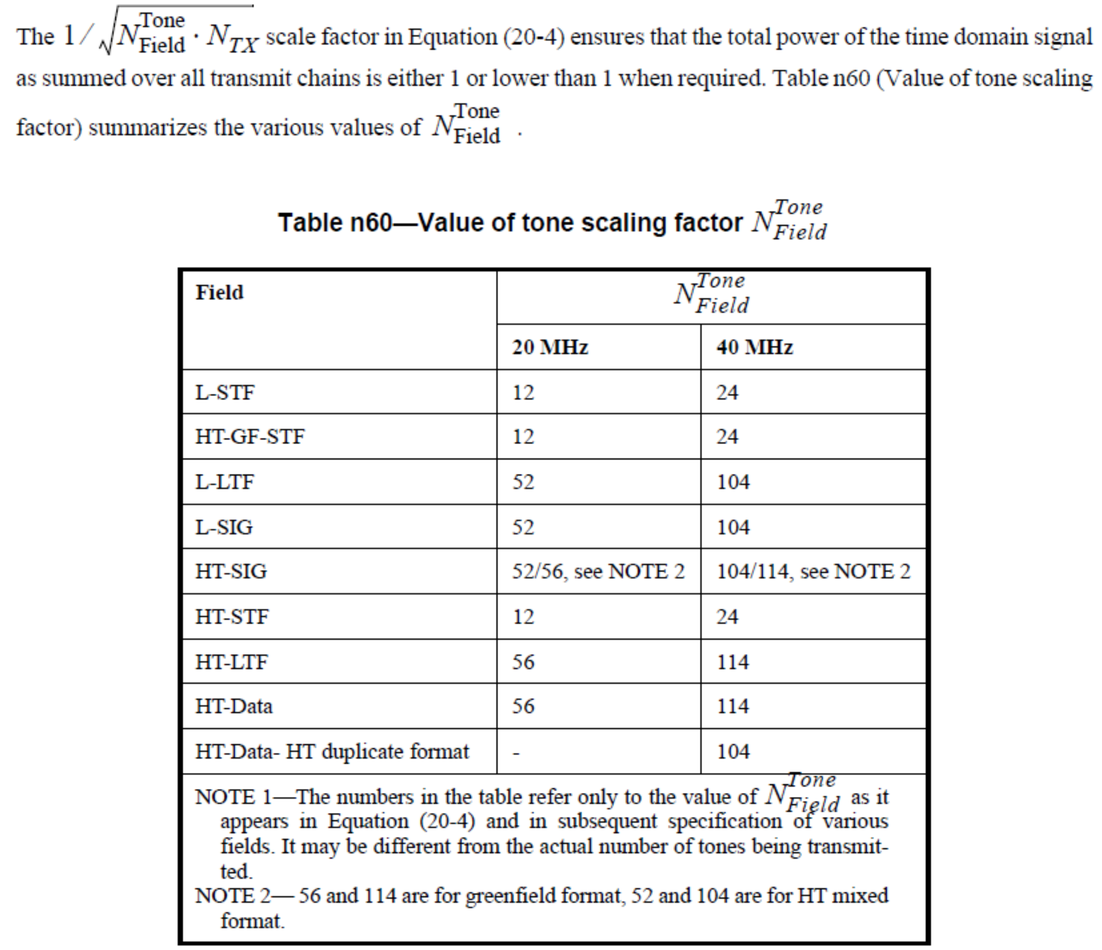
$$r^{(i_{TX})}_{\text{Field}}(t) = \frac{1}{\sqrt{N^{\text{Tone}}_{\text{Field}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X^{(i_{TX})}_k \exp(j 2 \pi k \Delta_F t) \qquad (20\text{-}4)$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X^{(i_{TX})}_k$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \qquad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \qquad (20\text{-}6)$$

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	

The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	40 MHz
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

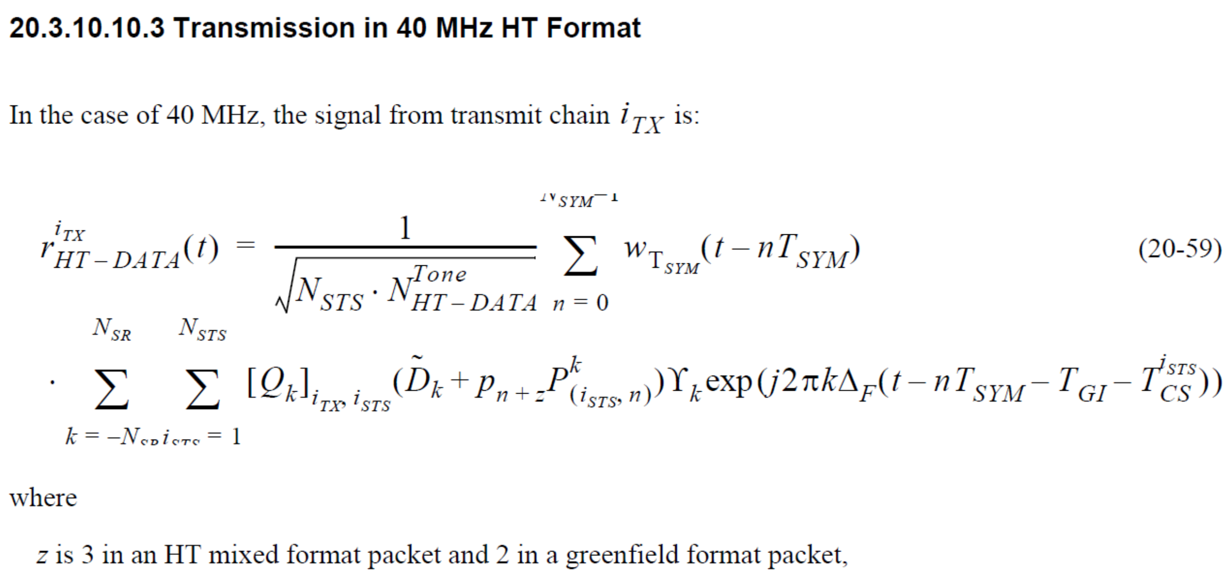
NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

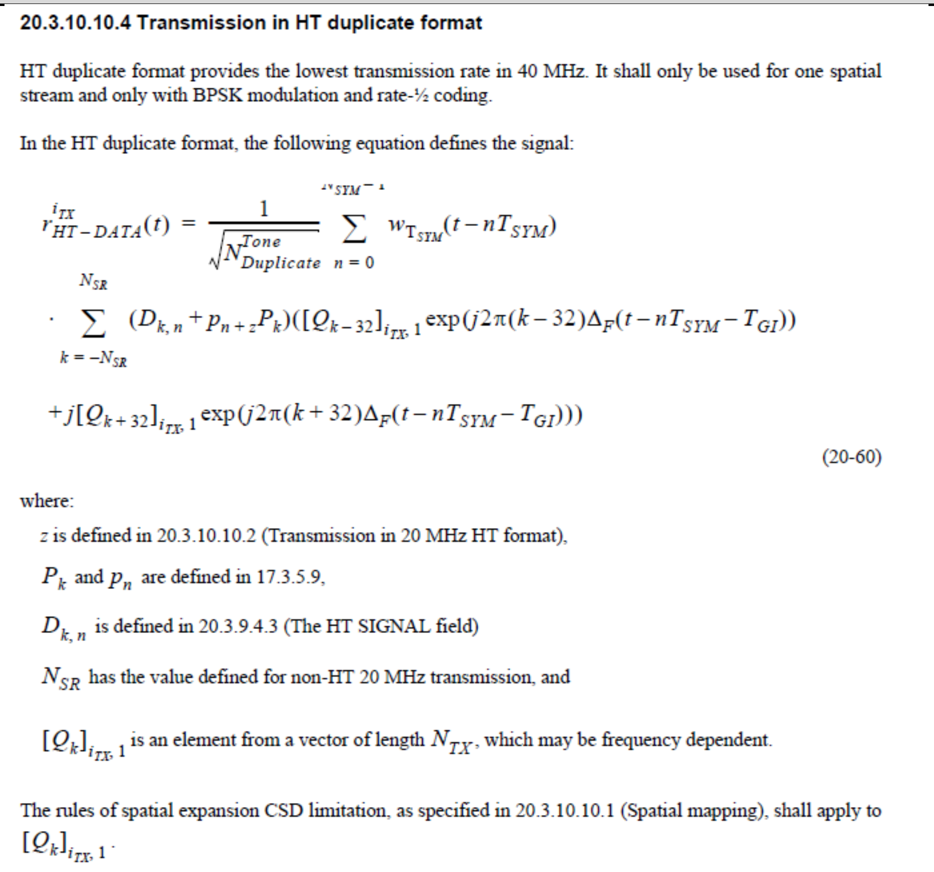
See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

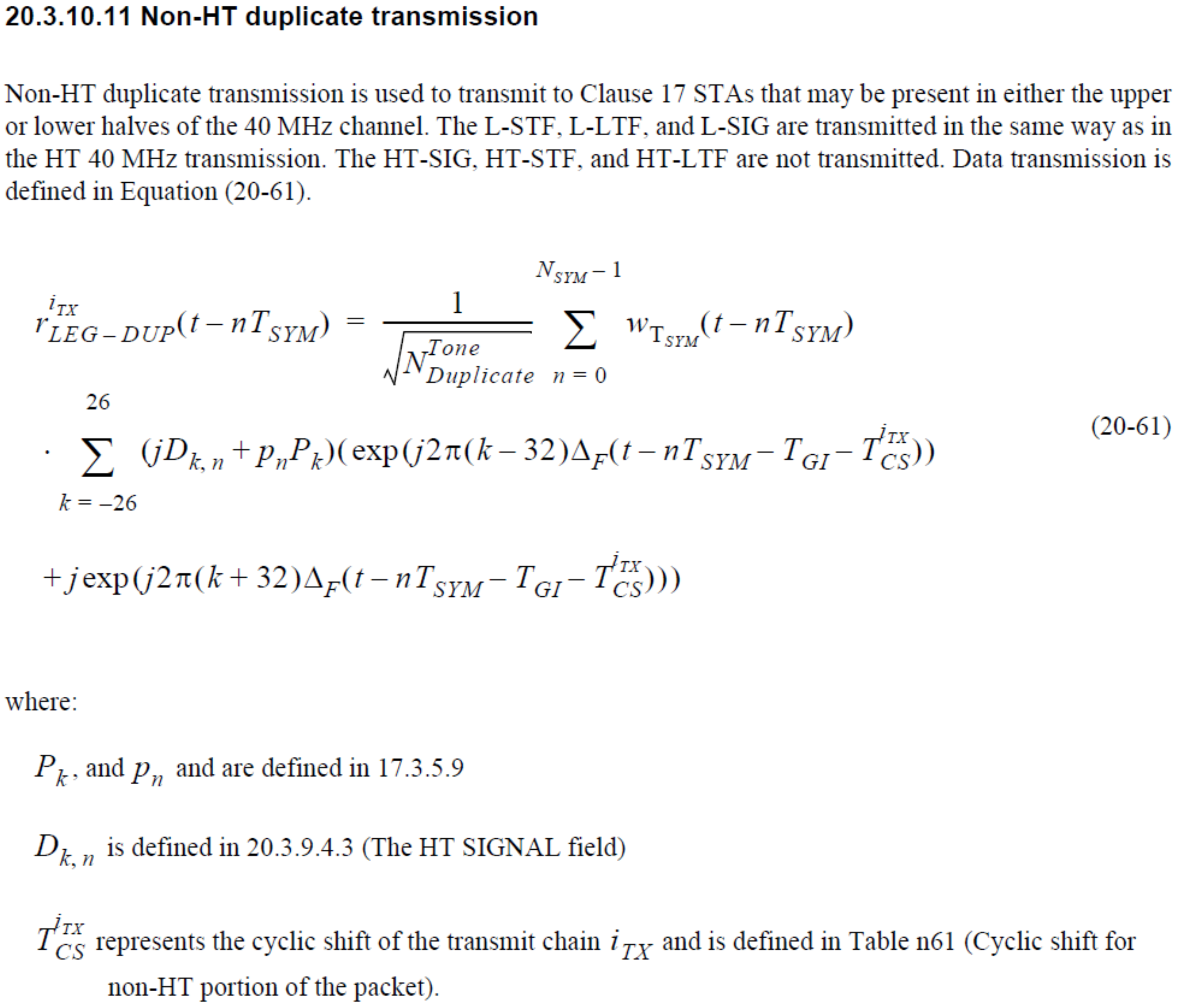
20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

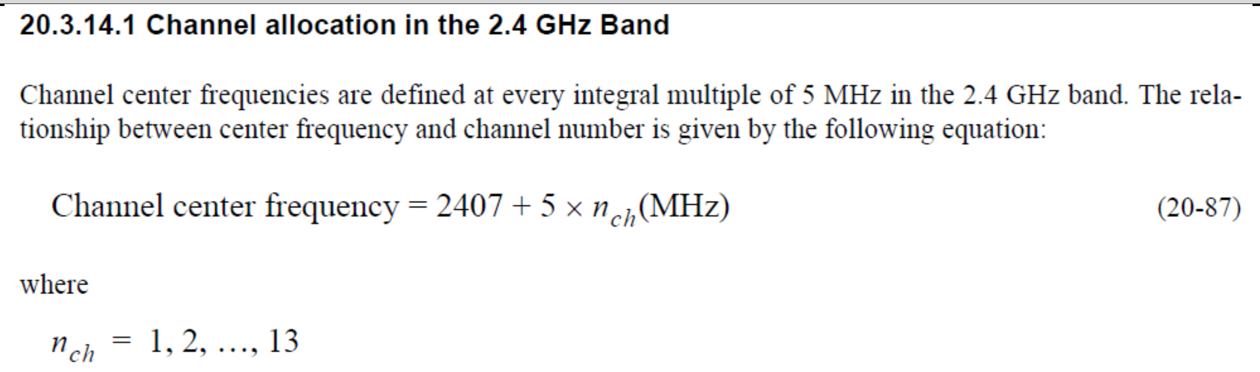
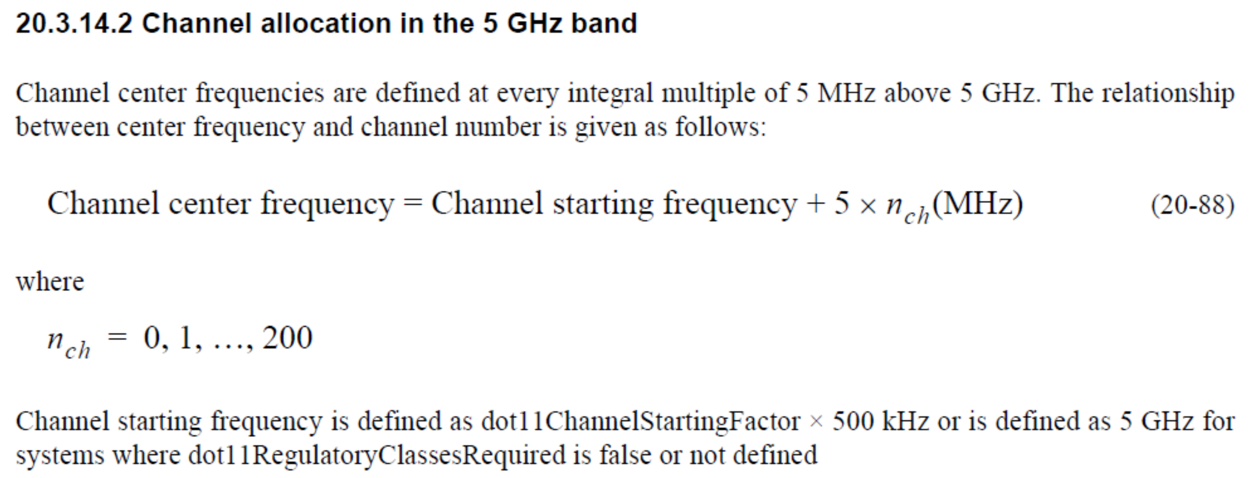
When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

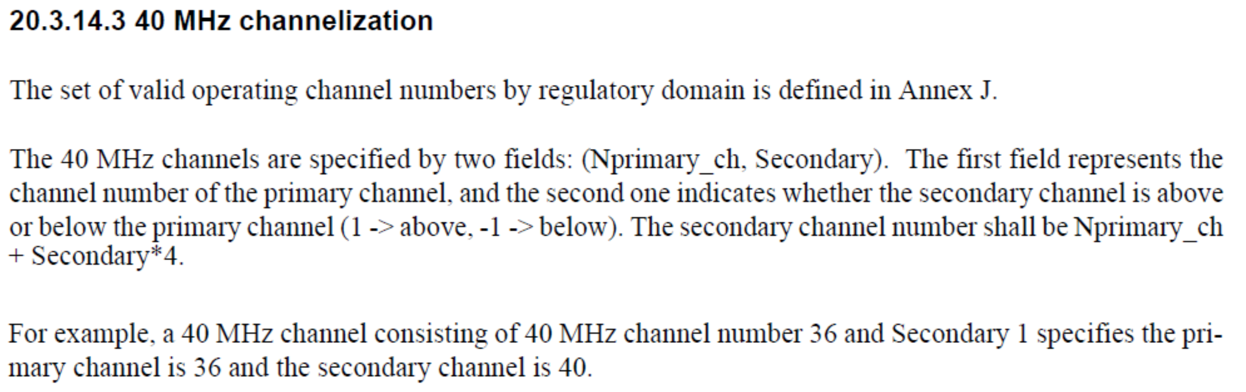
Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $$D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $$r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \quad (20\text{-}58)$$ $$\cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P_{(i_{STS}, n)}^k) \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$$ where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS} \cdot N^{Tone}_{HT-DATA}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P^k_{(i_{STS}, n)}) \Upsilon_k \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T^{i_{STS}}_{CS}))$ (20-59) where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM})$ $\cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n} + p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t - nT_{SYM} - T_{GI}))$ $+ j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t - nT_{SYM} - T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r_{LEG-DUP}^{i_{TX}}(t-nT_{SYM}) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n}+p_nP_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{TX}})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{TX}})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T_{CS}^{i_{TX}}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz})$ (20-87) where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz})$ (20-88) where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

<table>
<tr><th>Claim 10 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>See, e.g., 802.11n D2.0 § 20.3.20.3

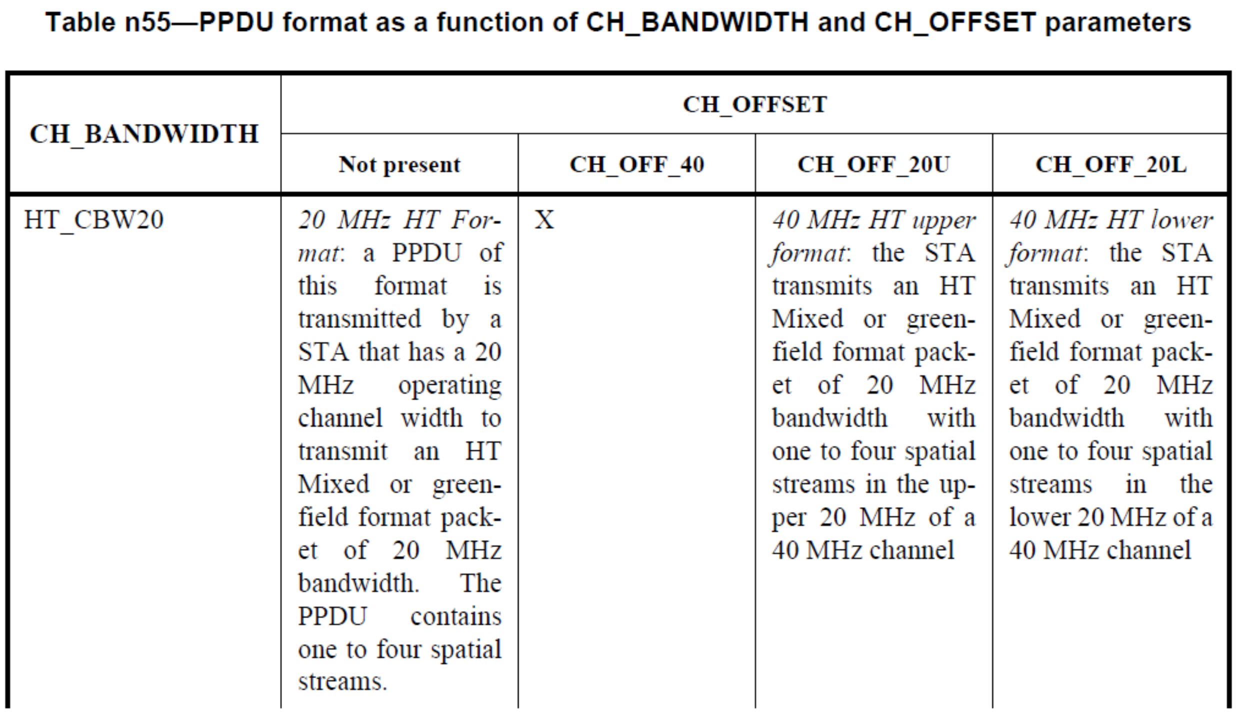
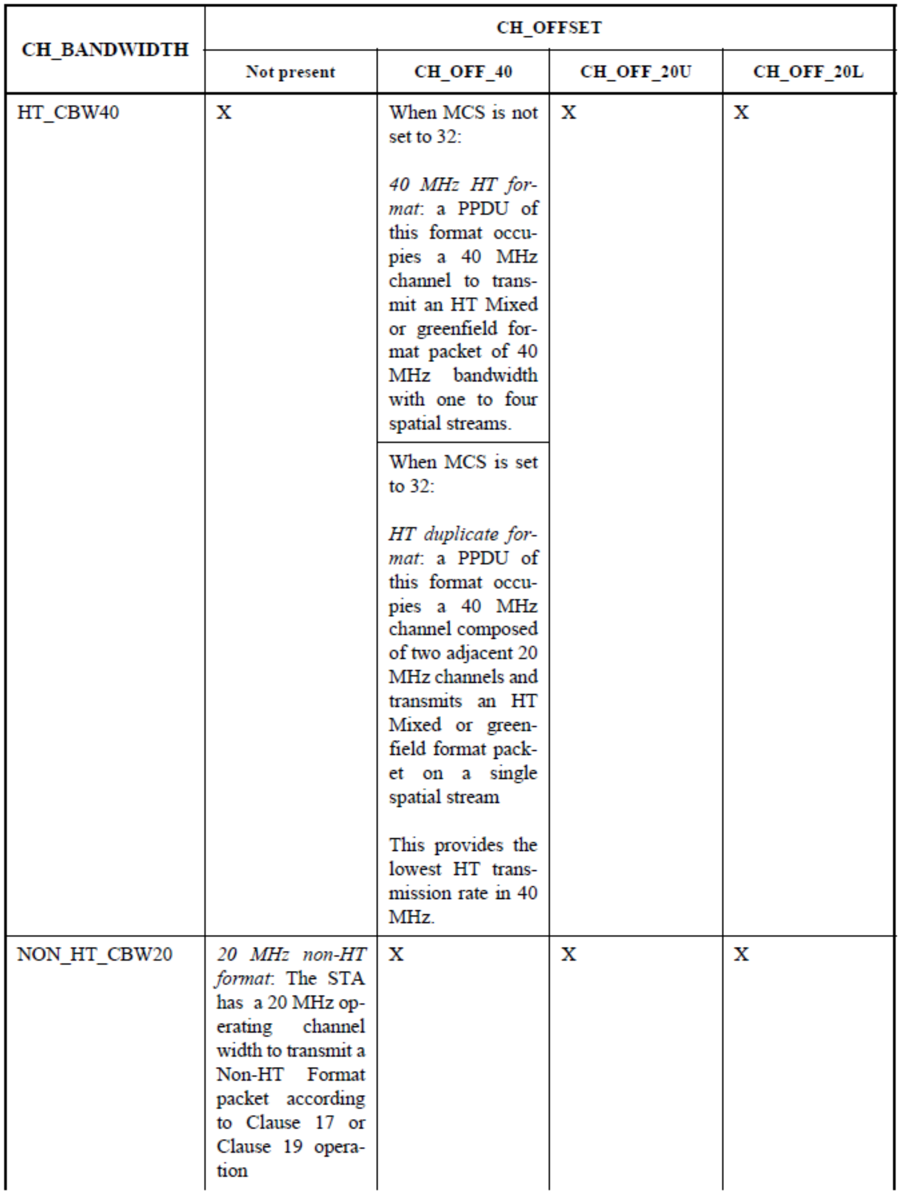
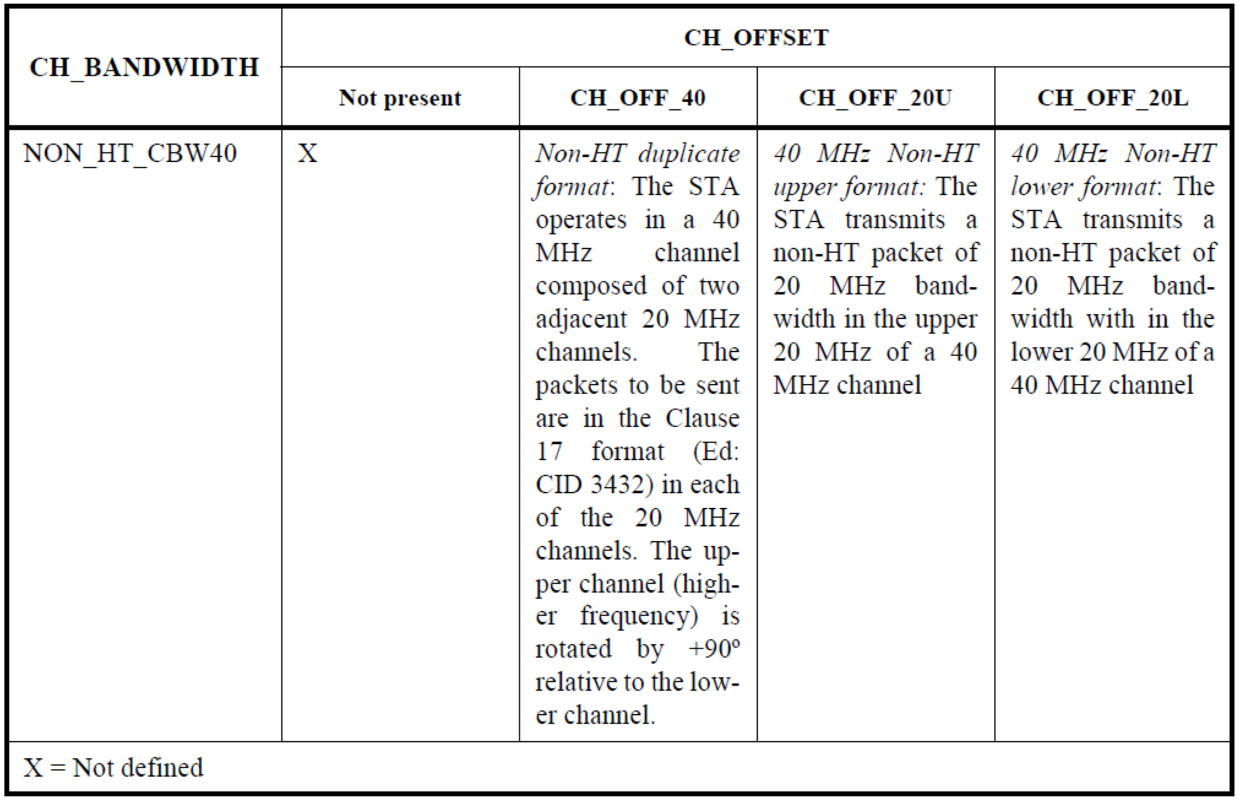



Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters
<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>HT_CBW20</td><td><i>20 MHz HT Format</i>: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.</td><td>X</td><td><i>40 MHz HT upper format</i>: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel</td><td><i>40 MHz HT lower format</i>: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel</td></tr>
</table>
</td></tr>
</table>



CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

<table>
<tr><th>Claim 10 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>NON_HT_CBW40</td><td>X</td><td>*Non-HT duplicate format*: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.</td><td>*40 MHz Non-HT upper format:* The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel</td><td>*40 MHz Non-HT lower format*: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel</td></tr>
<tr><td colspan="5">X = Not defined</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n55
</td></tr>
</table>

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0

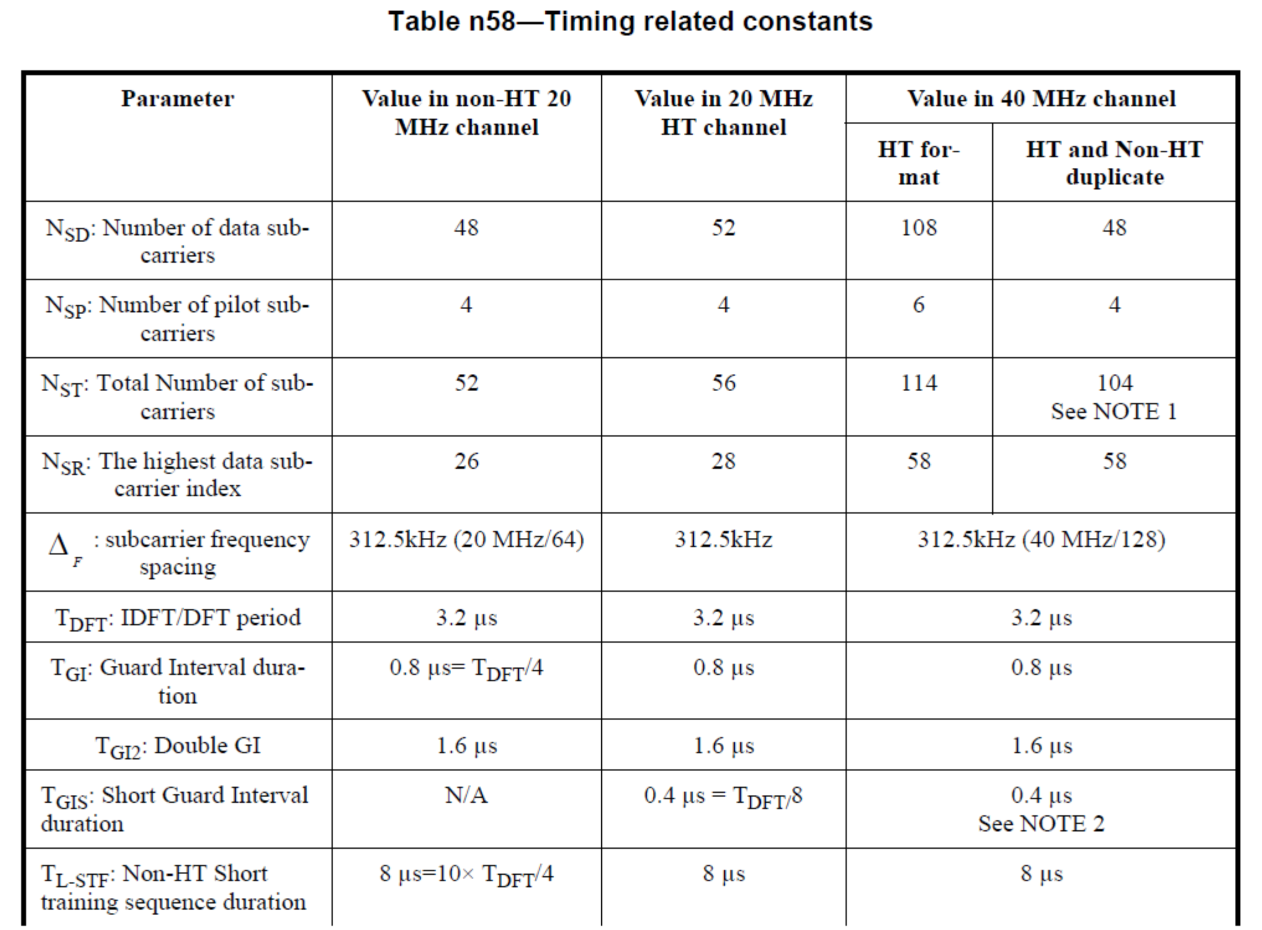
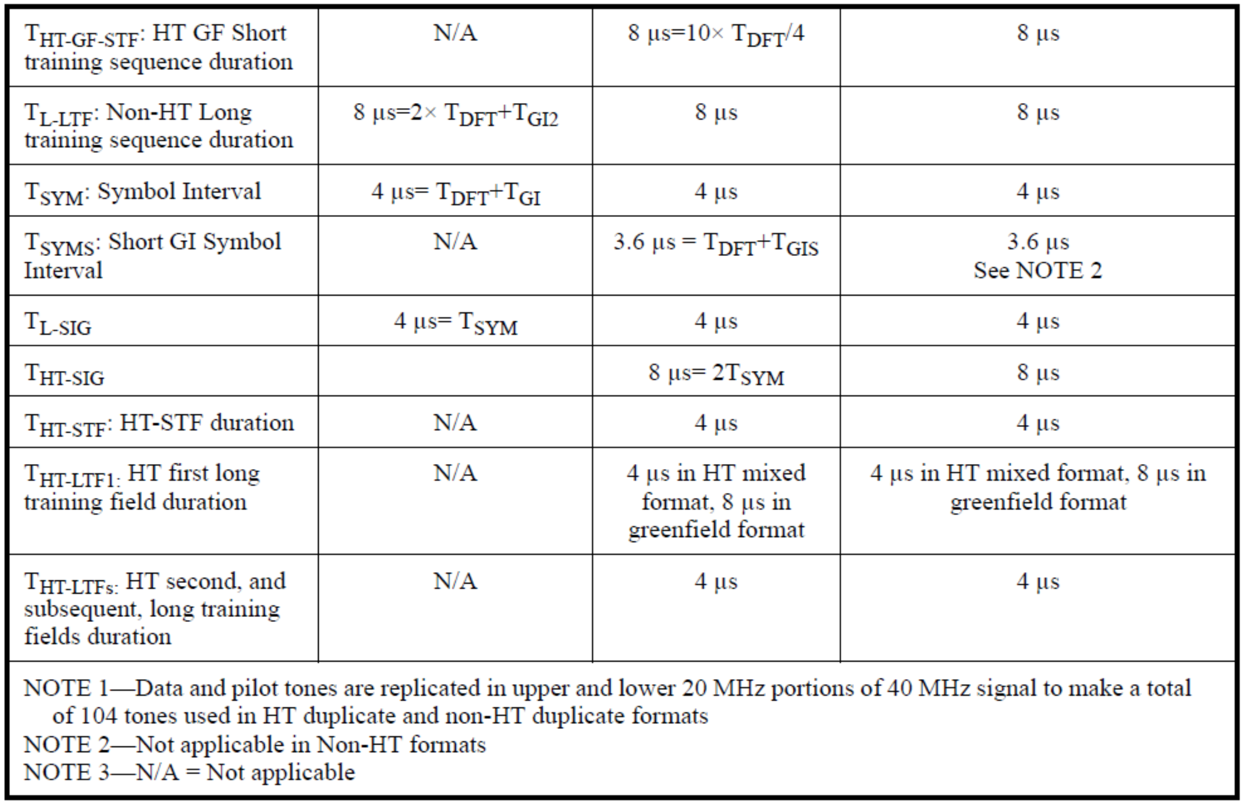


Table n58—Timing related constants

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

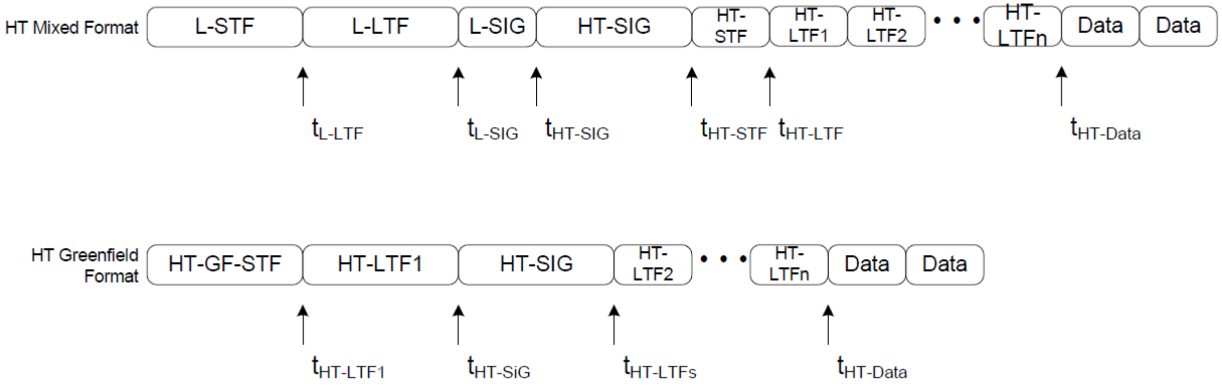
Claim 10 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**



$T_{HT\text{-}GF\text{-}STF}$: HT GF Short training sequence duration	N/A	8 µs=10× T_{DFT}/4	8 µs
$T_{L\text{-}LTF}$: Non-HT Long training sequence duration	8 µs=2× T_{DFT}+T_{GI2}	8 µs	8 µs
T_{SYM}: Symbol Interval	4 µs= T_{DFT}+T_{GI}	4 µs	4 µs
T_{SYMS}: Short GI Symbol Interval	N/A	3.6 µs = T_{DFT}+T_{GIS}	3.6 µs See NOTE 2
$T_{L\text{-}SIG}$	4 µs= T_{SYM}	4 µs	4 µs
$T_{HT\text{-}SIG}$		8 µs= 2T_{SYM}	8 µs
$T_{HT\text{-}STF}$: HT-STF duration	N/A	4 µs	4 µs
$T_{HT\text{-}LTF1}$: HT first long training field duration	N/A	4 µs in HT mixed format, 8 µs in greenfield format	4 µs in HT mixed format, 8 µs in greenfield format
$T_{HT\text{-}LTFs}$: HT second, and subsequent, long training fields duration	N/A	4 µs	4 µs

NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable

See, e.g., 802.11n D2.0 Table n58

Claim 10 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.
[10.9] amplifying the combined up-converted signal in a power amplifier resulting in an amplified combined up-converted signal; and	802.11n D2.0 discloses “amplifying the combined up-converted signal in a power amplifier resulting in an amplified combined up-converted signal.” See, e.g.: **high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19 **non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission.

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0

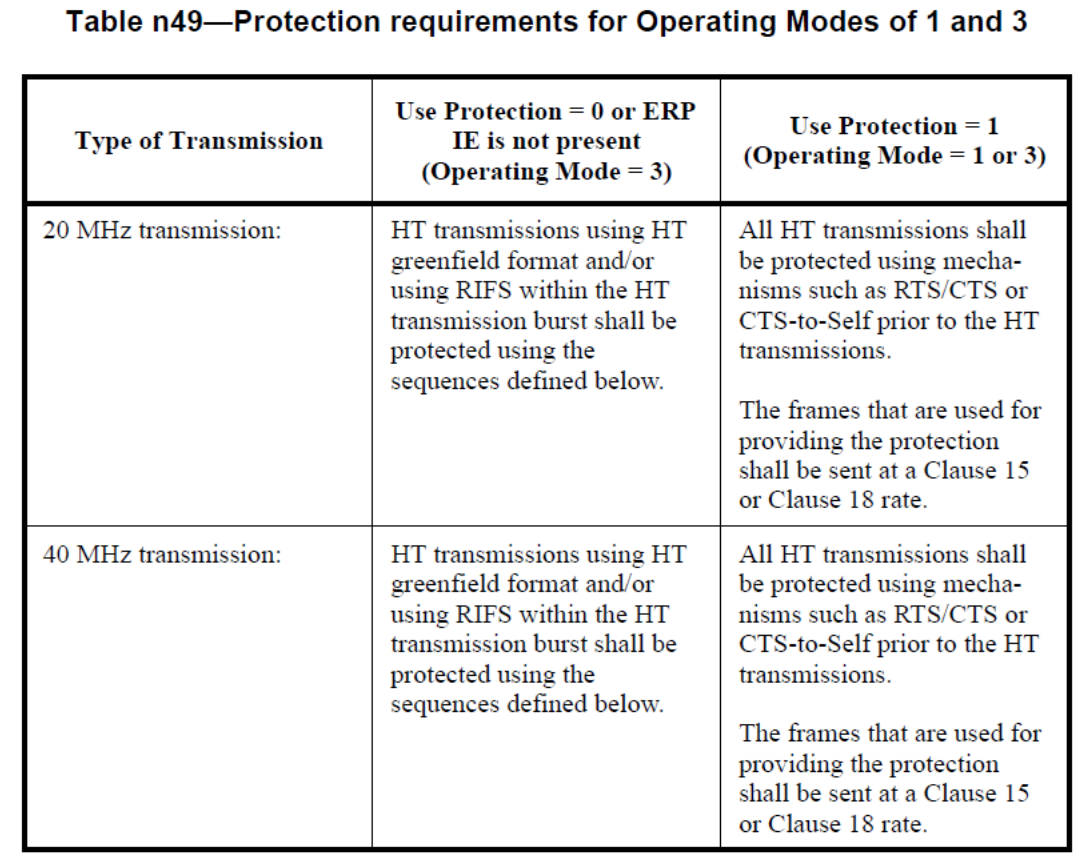


Table n49—Protection requirements for Operating Modes of 1 and 3

Type of Transmission	Use Protection = 0 or ERP IE is not present (Operating Mode = 3)	Use Protection = 1 (Operating Mode = 1 or 3)
20 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.
40 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.
NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).

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	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

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	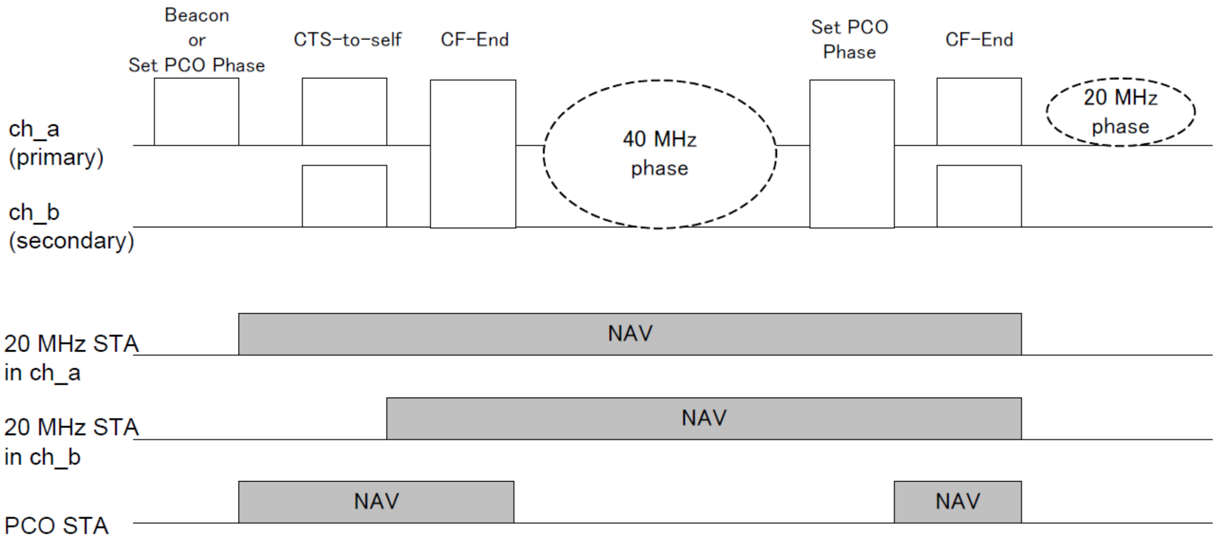 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format*: packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format*: packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format*: HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

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	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

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	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

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	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

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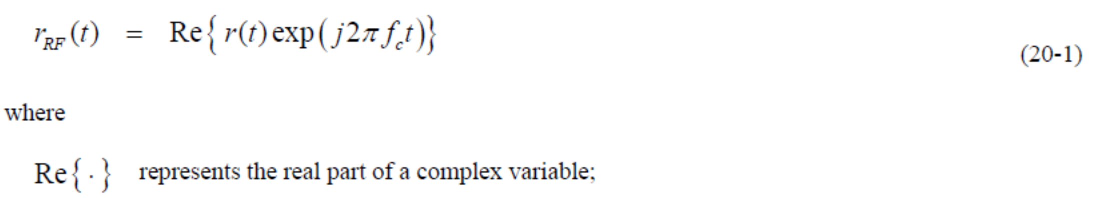
	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation:  $r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t \right) \right\}$ (20-1) where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

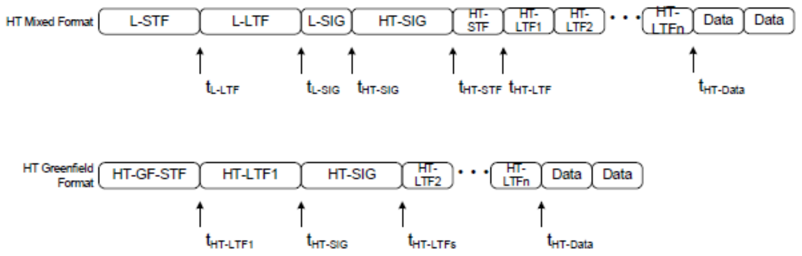


Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF}-1\right)T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \tag{20-2}$$

where

$$t_{L-LTF} = T_{L-STF}$$

$$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$$

$$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$$

$$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1}) \\ & + r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2)T_{HT-LTFs}) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \qquad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\text{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\text{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j 2\pi k \Delta_F t) \qquad (20\text{-}4)$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \leq 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \qquad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \qquad (20\text{-}6)$$

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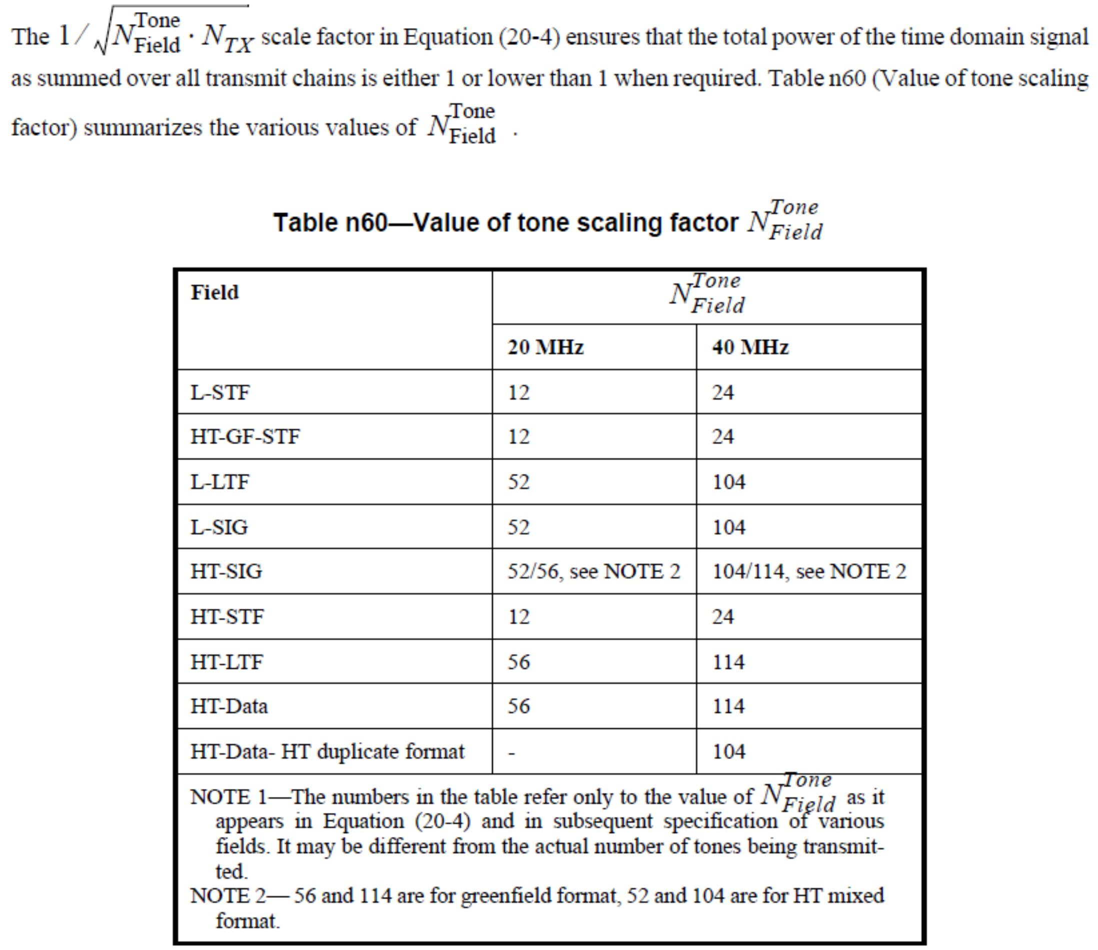

The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	**40 MHz**
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

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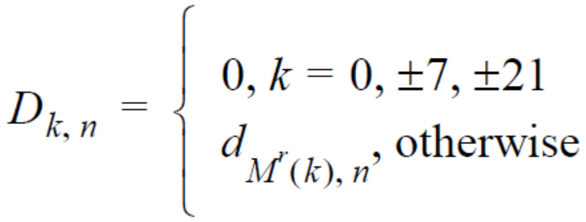
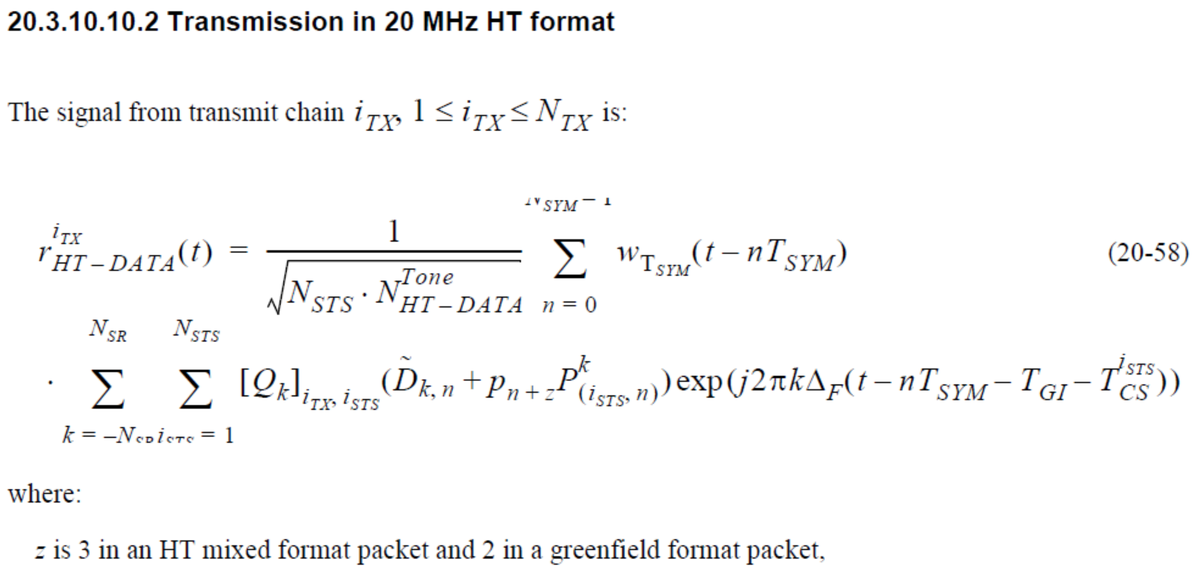
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS} \cdot N^{Tone}_{HT-DATA}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P^k_{(i_{STS}, n)}) \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T^{i_{STS}}_{CS}))$ (20-58) where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

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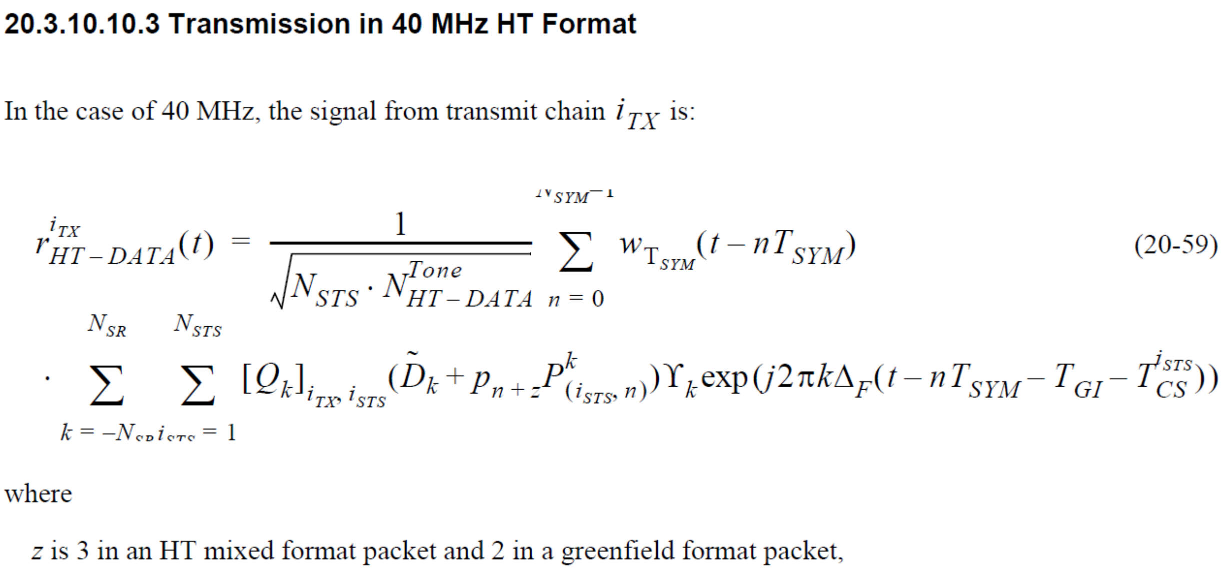
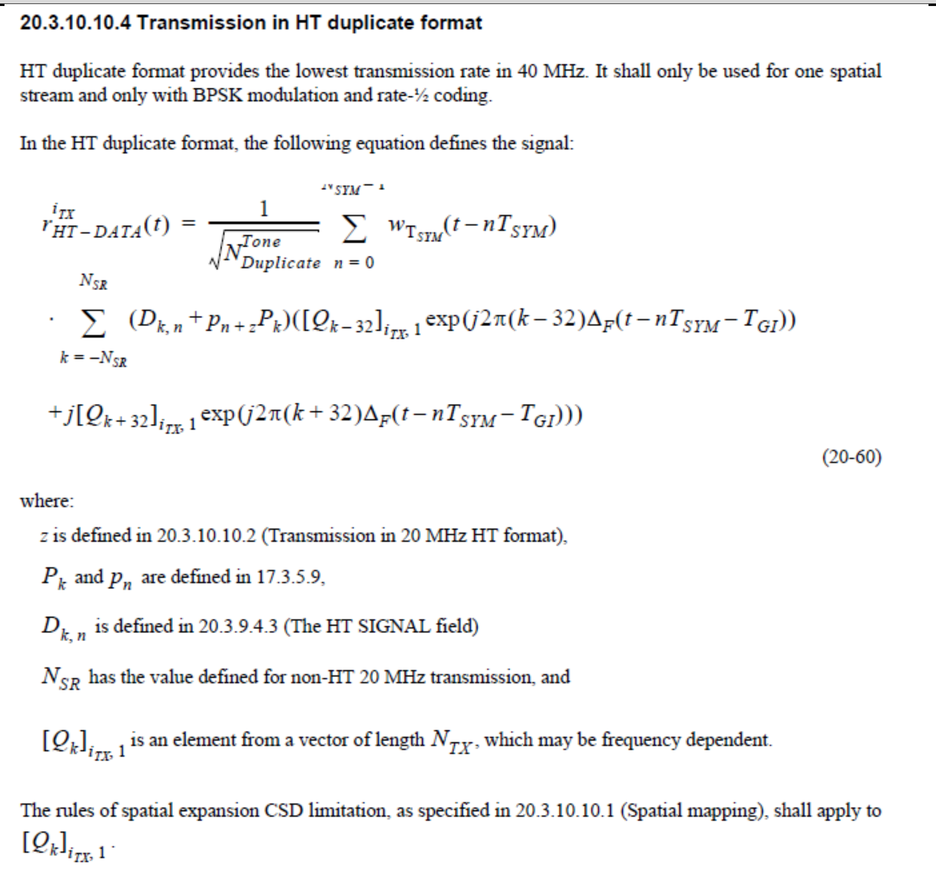
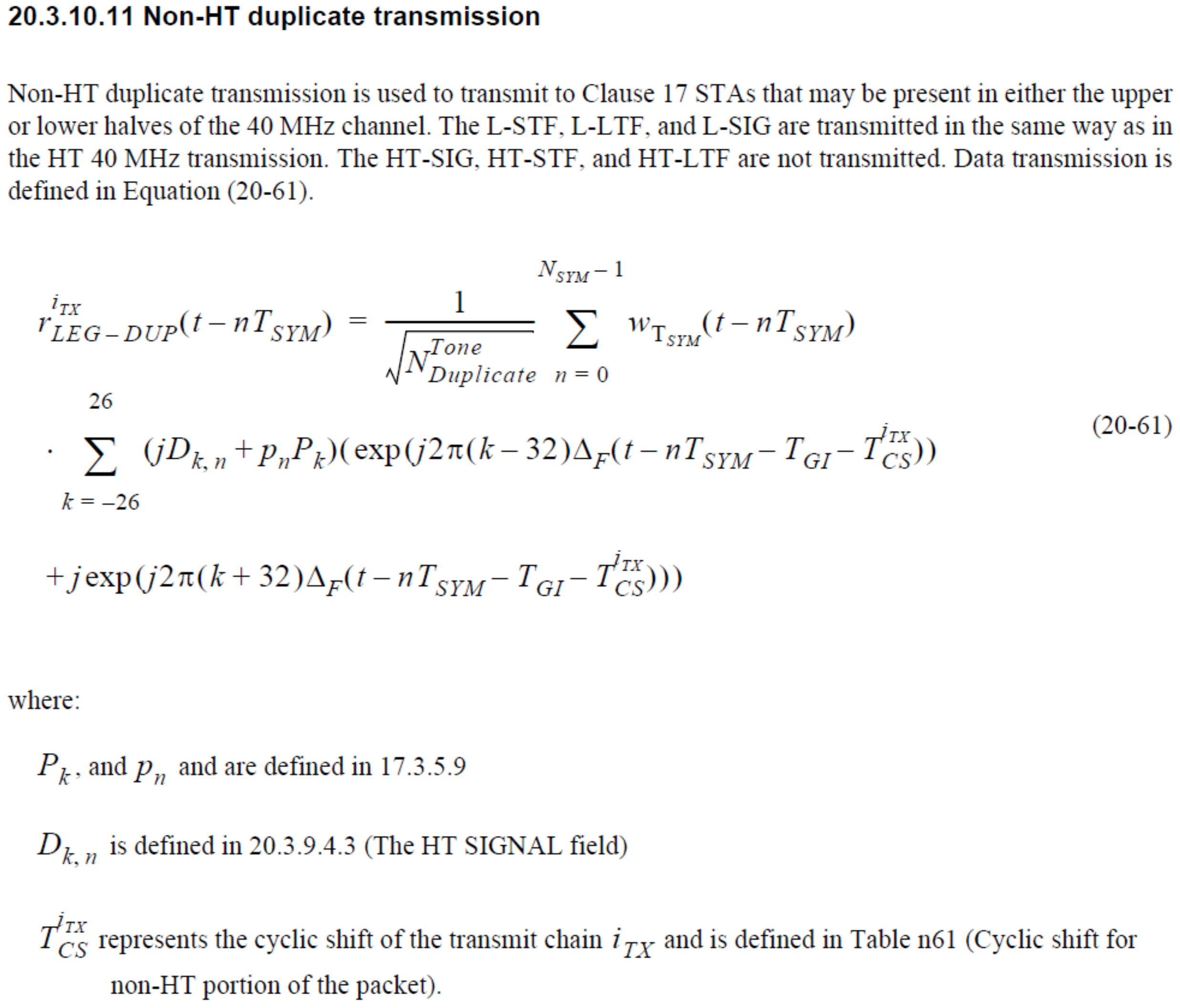
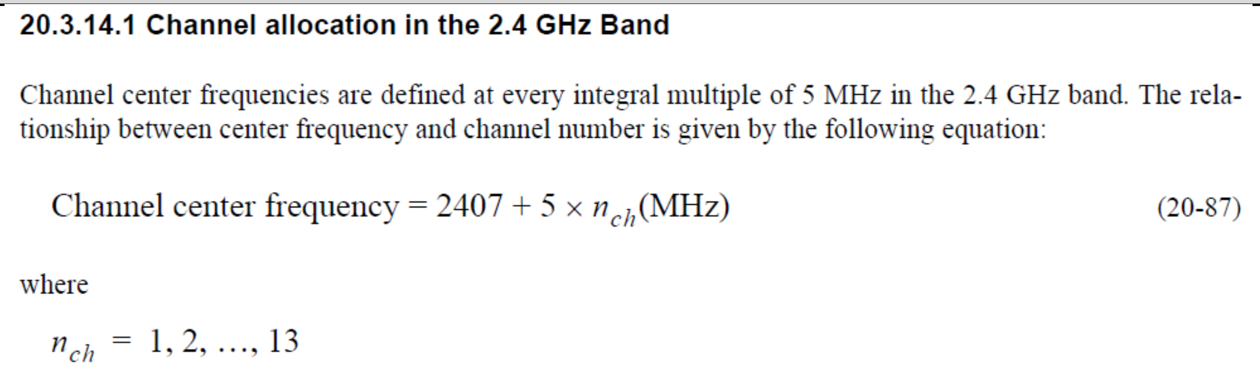
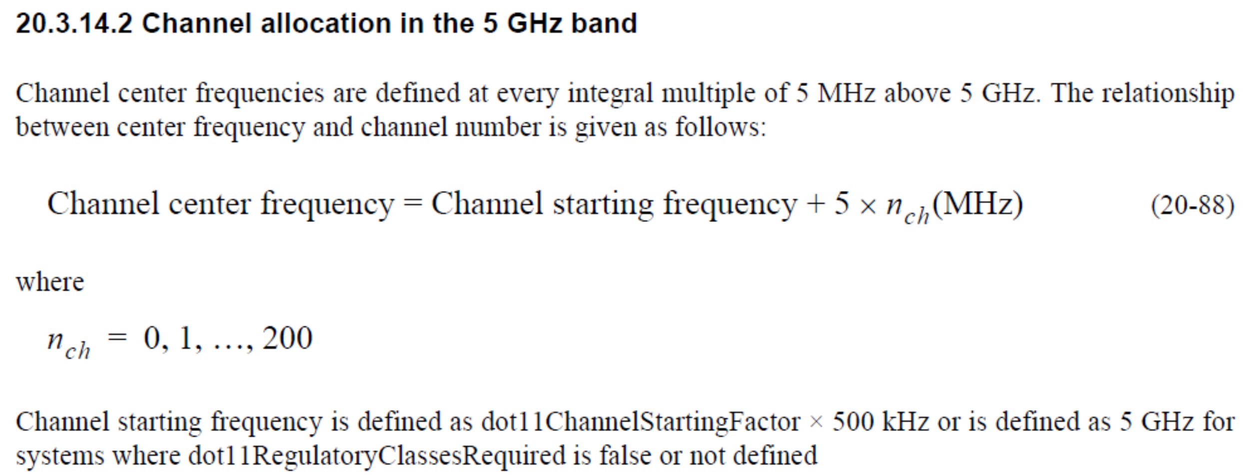
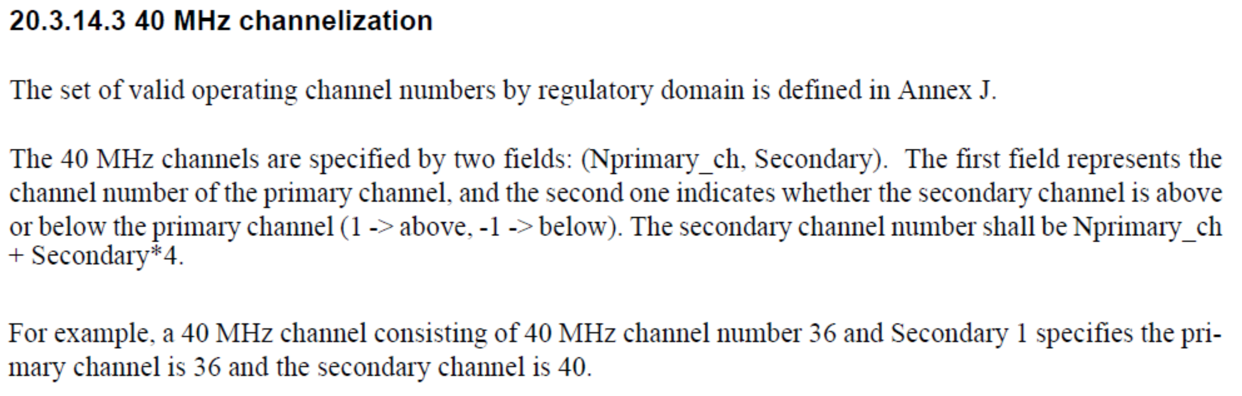
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P_{(i_{STS}, n)}^{k}) \Upsilon_k \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (20-59) where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n} + p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI})) + j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r_{LEG-DUP}^{i_{TX}}(t-nT_{SYM}) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n}+p_nP_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{TX}})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{TX}})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T_{CS}^{i_{TX}}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz})$ (20-87) where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz})$ (20-88) where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

<table>
<tr><th>Claim 10 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>See, e.g., 802.11n D2.0 § 20.3.20.3

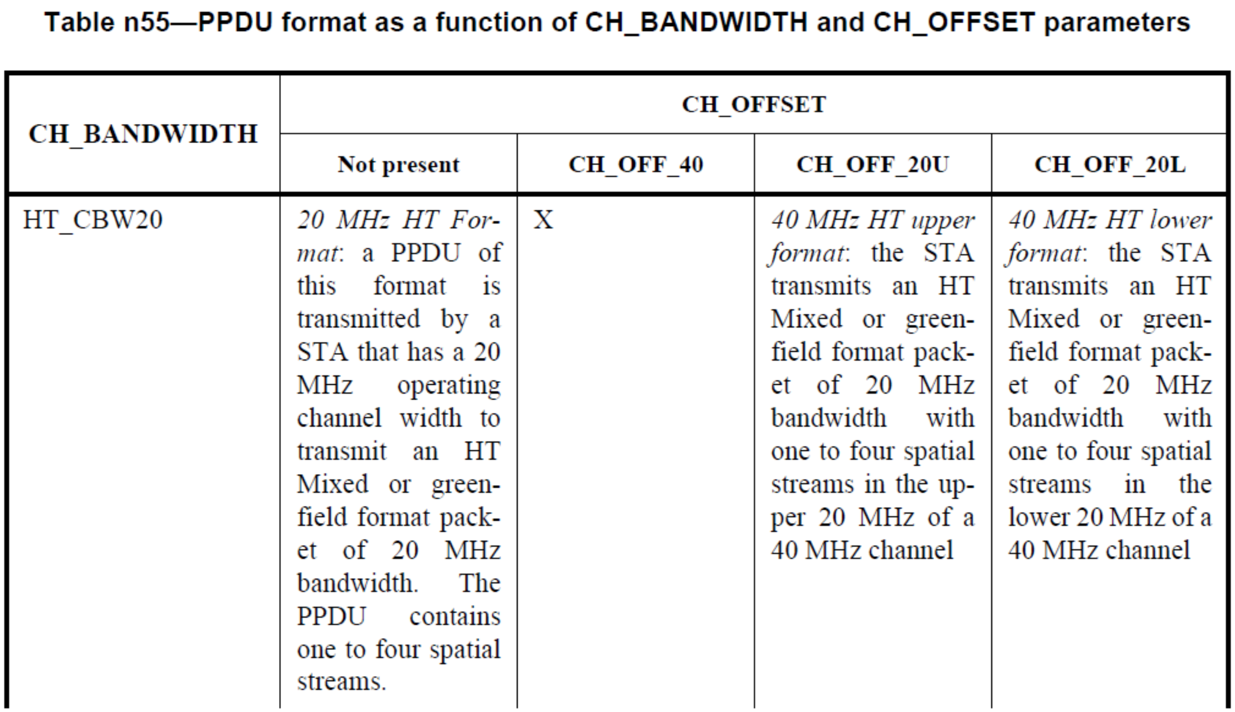
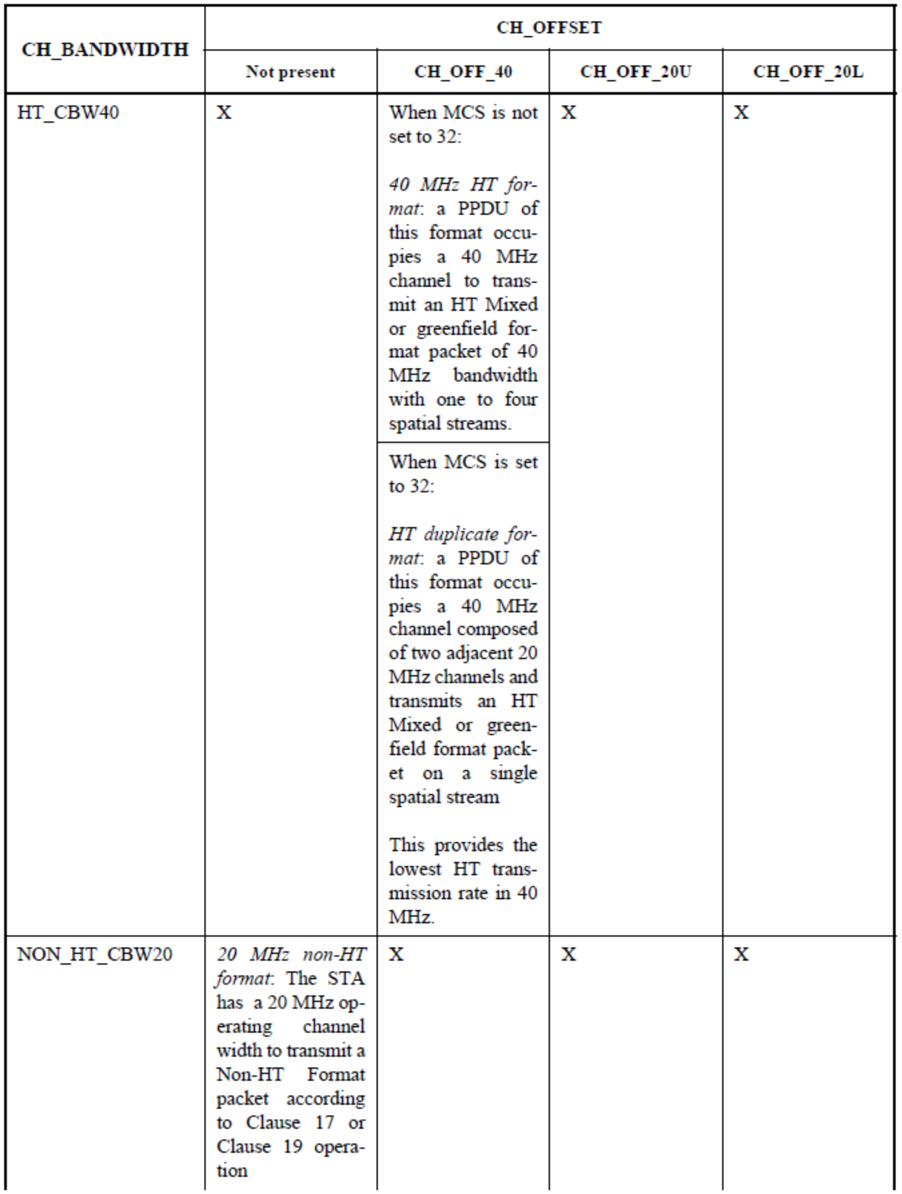
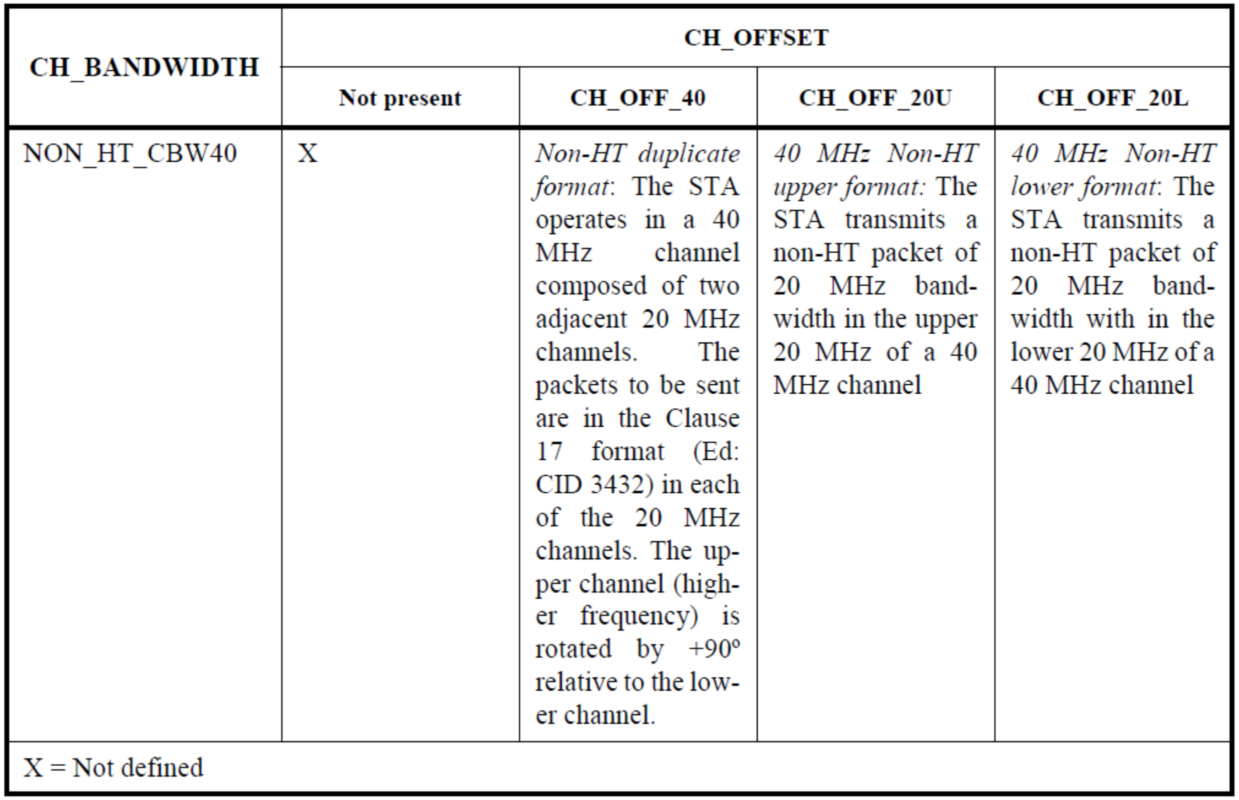
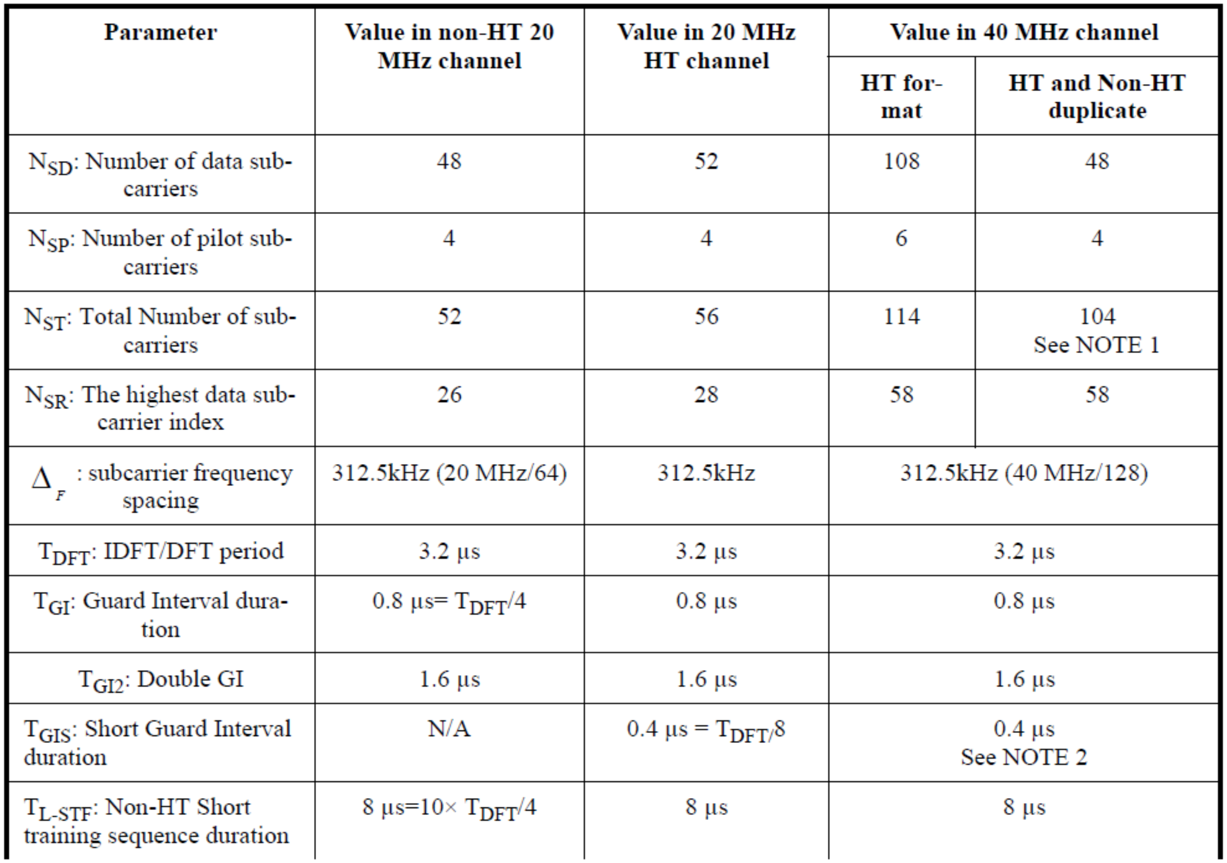



Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters
<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>HT_CBW20</td><td><i>20 MHz HT Format</i>: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or green-field format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.</td><td>X</td><td><i>40 MHz HT upper format</i>: the STA transmits an HT Mixed or green-field format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel</td><td><i>40 MHz HT lower format</i>: the STA transmits an HT Mixed or green-field format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel</td></tr>
</table>
</td></tr>
</table>



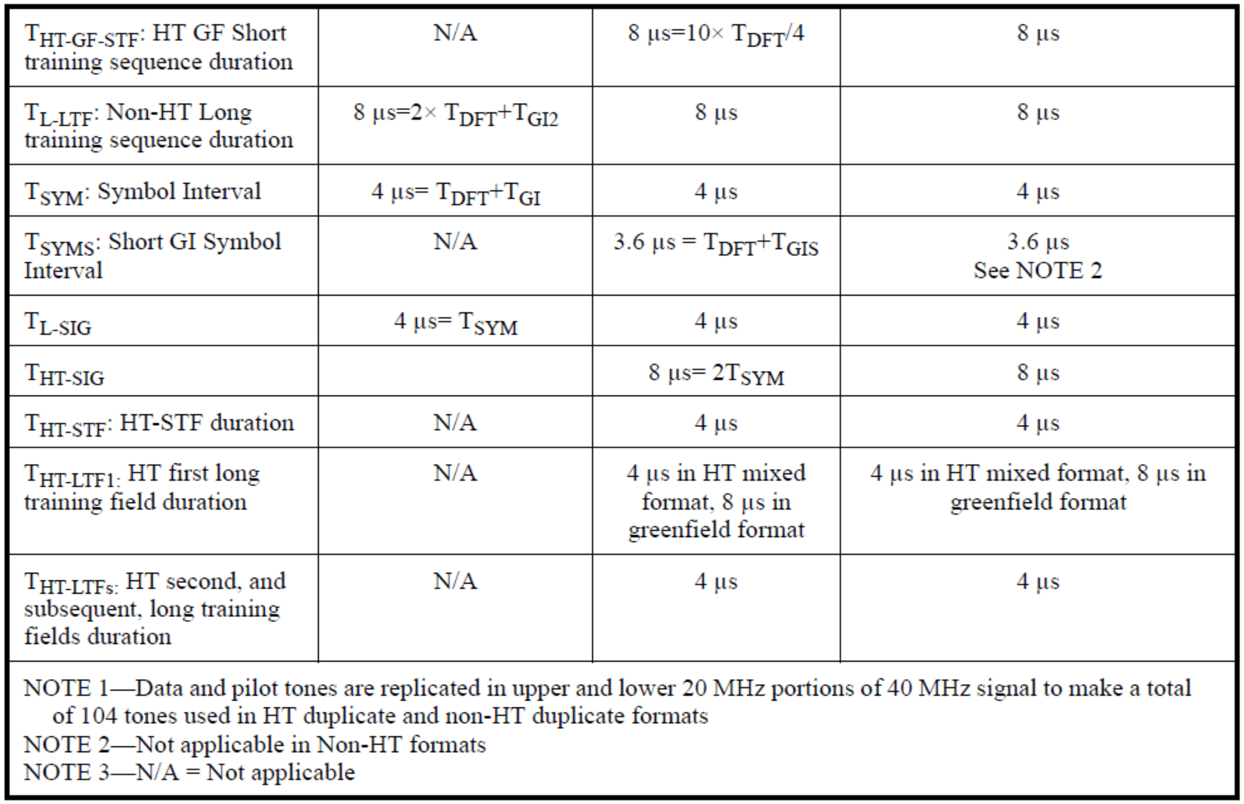
CH_BANDWIDTH	**CH_OFFSET**			
	Not present	**CH_OFF_40**	**CH_OFF_20U**	**CH_OFF_20L**
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

<table>
<tr><th>Claim 10 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>NON_HT_CBW40</td><td>X</td><td>Non-HT duplicate format: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.</td><td>40 MHz Non-HT upper format: The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel</td><td>40 MHz Non-HT lower format: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel</td></tr>
<tr><td colspan="5">X = Not defined</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n55
</td></tr>
</table>

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	Table n58—Timing related constants 

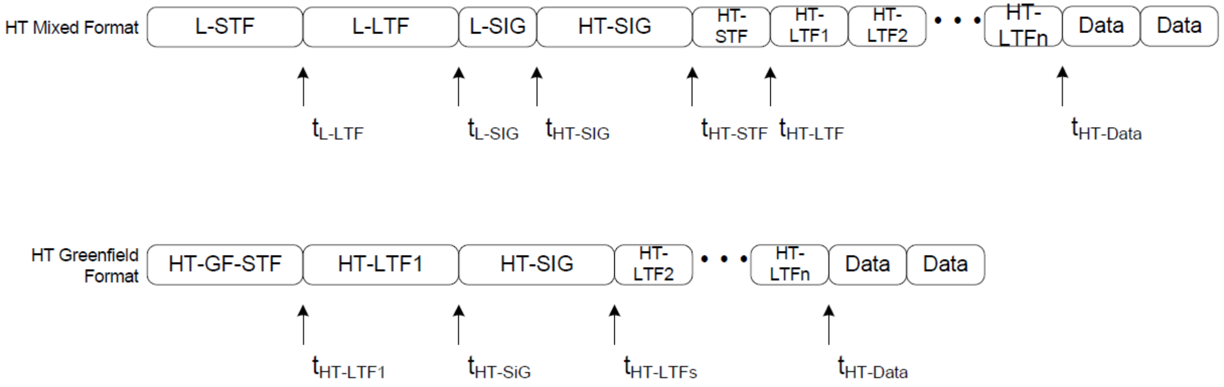
Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

Claim 10 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**



$T_{HT\text{-}GF\text{-}STF}$: HT GF Short training sequence duration	N/A	8 μs=10× T_{DFT}/4	8 μs
$T_{L\text{-}LTF}$: Non-HT Long training sequence duration	8 μs=2× T_{DFT}+T_{GI2}	8 μs	8 μs
T_{SYM}: Symbol Interval	4 μs= T_{DFT}+T_{GI}	4 μs	4 μs
T_{SYMS}: Short GI Symbol Interval	N/A	3.6 μs = T_{DFT}+T_{GIS}	3.6 μs See NOTE 2
$T_{L\text{-}SIG}$	4 μs= T_{SYM}	4 μs	4 μs
$T_{HT\text{-}SIG}$		8 μs= 2T_{SYM}	8 μs
$T_{HT\text{-}STF}$: HT-STF duration	N/A	4 μs	4 μs
$T_{HT\text{-}LTF1}$: HT first long training field duration	N/A	4 μs in HT mixed format, 8 μs in greenfield format	4 μs in HT mixed format, 8 μs in greenfield format
$T_{HT\text{-}LTFs}$: HT second, and subsequent, long training fields duration	N/A	4 μs	4 μs
NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats NOTE 2—Not applicable in Non-HT formats NOTE 3—N/A = Not applicable			

See, e.g., 802.11n D2.0 Table n58

Claim 10 of the '802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.
[10.10] transmitting the amplified combined up-converted signal on a first antenna,	802.11n D2.0 discloses "transmitting the amplified combined up-converted signal on a first antenna." See, e.g.: **high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19 **non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission.

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0

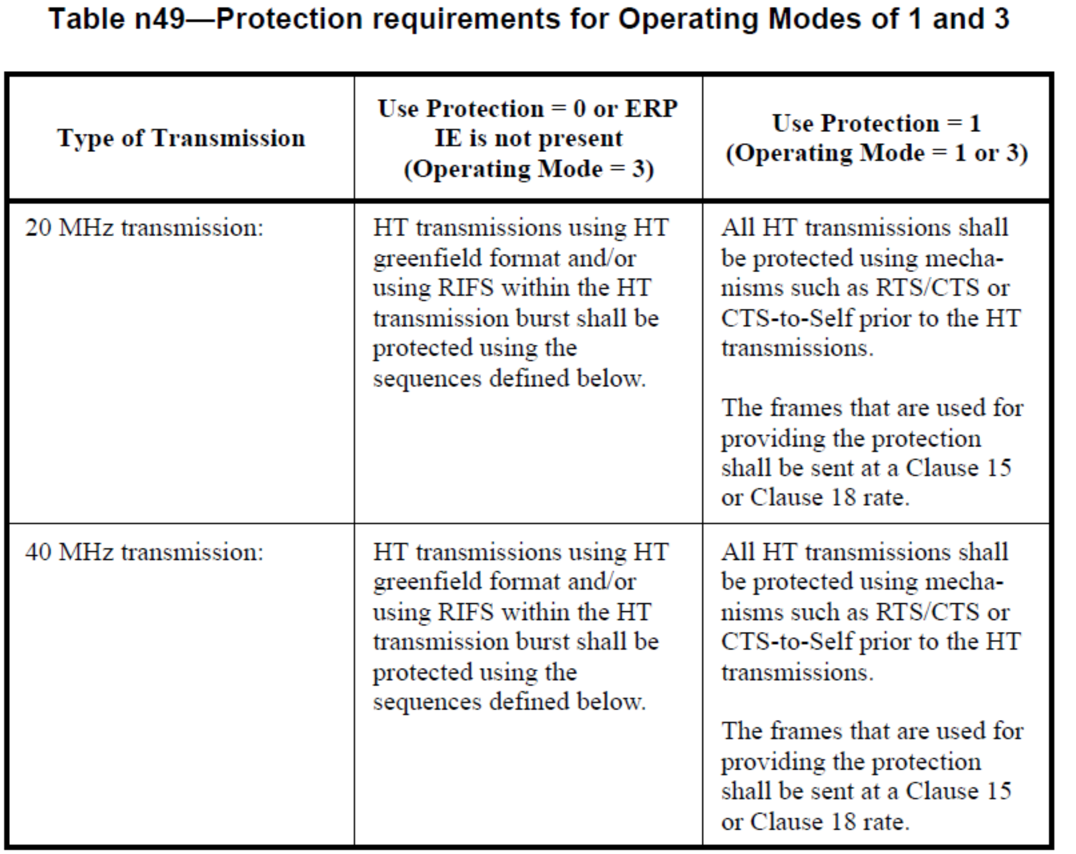
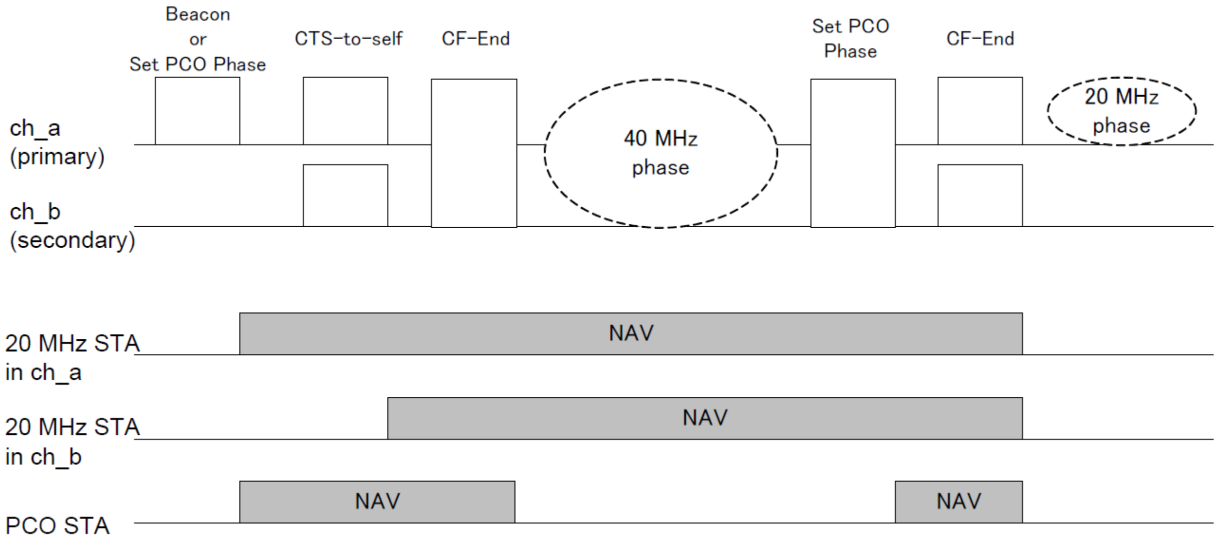


Table n49—Protection requirements for Operating Modes of 1 and 3

Type of Transmission	Use Protection = 0 or ERP IE is not present (Operating Mode = 3)	Use Protection = 1 (Operating Mode = 1 or 3)
20 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.
40 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.
NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

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	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t \right) \right\}$ (20-1) where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

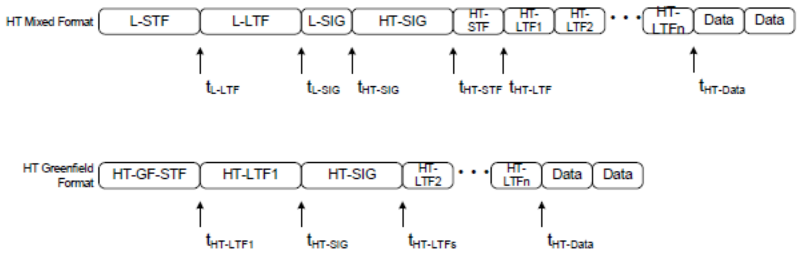

Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right)T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}\left(t - t_{HT-DATA}\right) \end{aligned} \qquad (20\text{-}2)$$

where

$$t_{L-LTF} = T_{L-STF}$$

$$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$$

$$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$$

$$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$r_{PPDU}^{(i_{TX})}(t) = r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1})$$

$$+ r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG})$$

$$+ \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2)T_{HT-LTFs})$$

$$+ r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \quad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\text{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\text{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j 2\pi k \Delta_F t) \quad (20\text{-}4)$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \quad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \quad (20\text{-}6)$$

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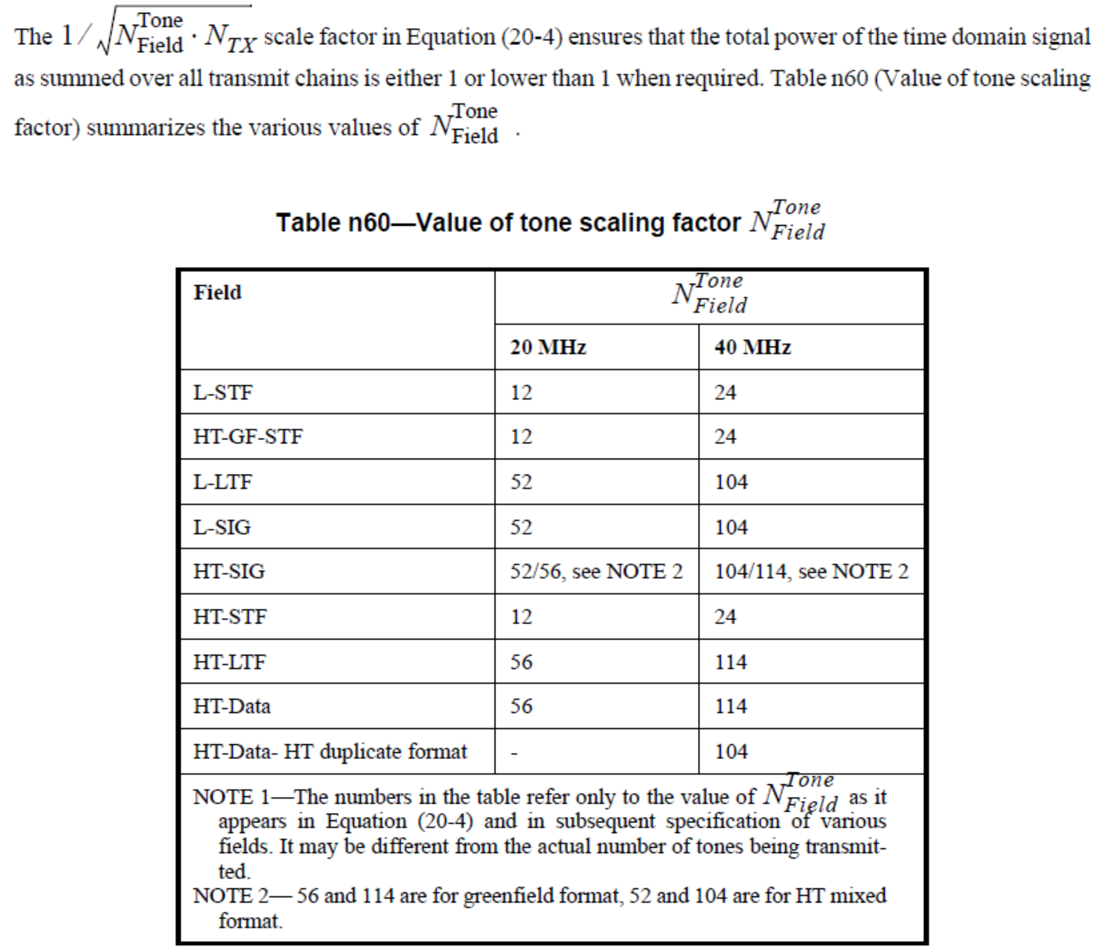

The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	**40 MHz**
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

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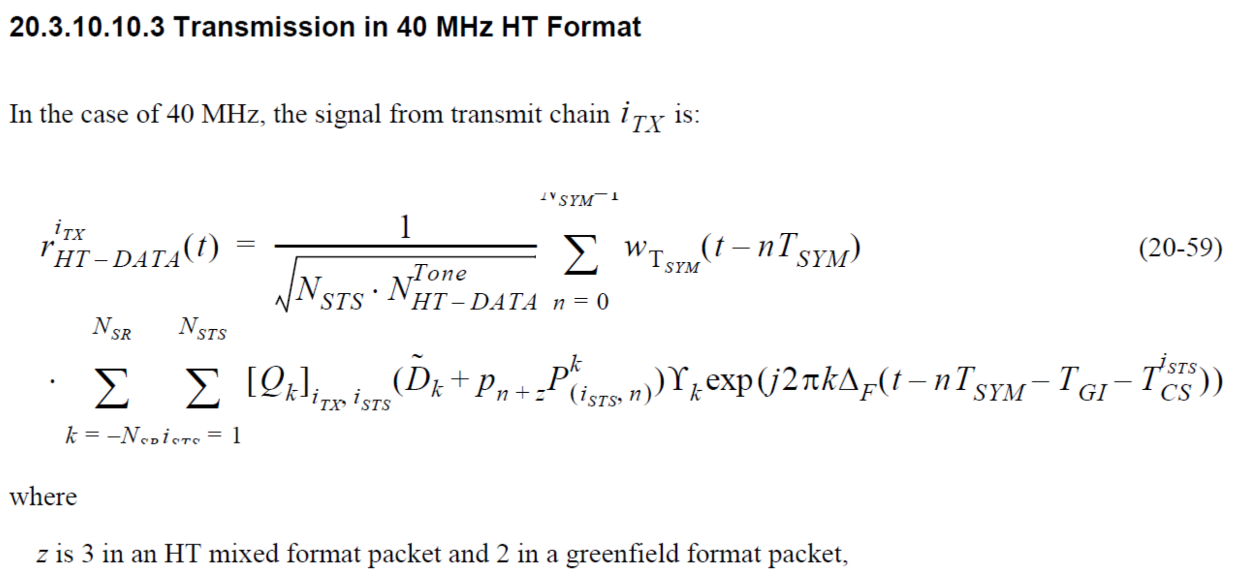
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $$D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $$r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P_{(i_{STS},n)}^k) \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}})) \quad (20\text{-}58)$$ where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

<table>
<tr><th>Claim 10 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

See, e.g., 802.11n D2.0 § 20.3.10.10.2



20.3.10.10.3 Transmission in 40 MHz HT Format

In the case of 40 MHz, the signal from transmit chain i_{TX} is:

$$r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS}\cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \quad (20\text{-}59)$$

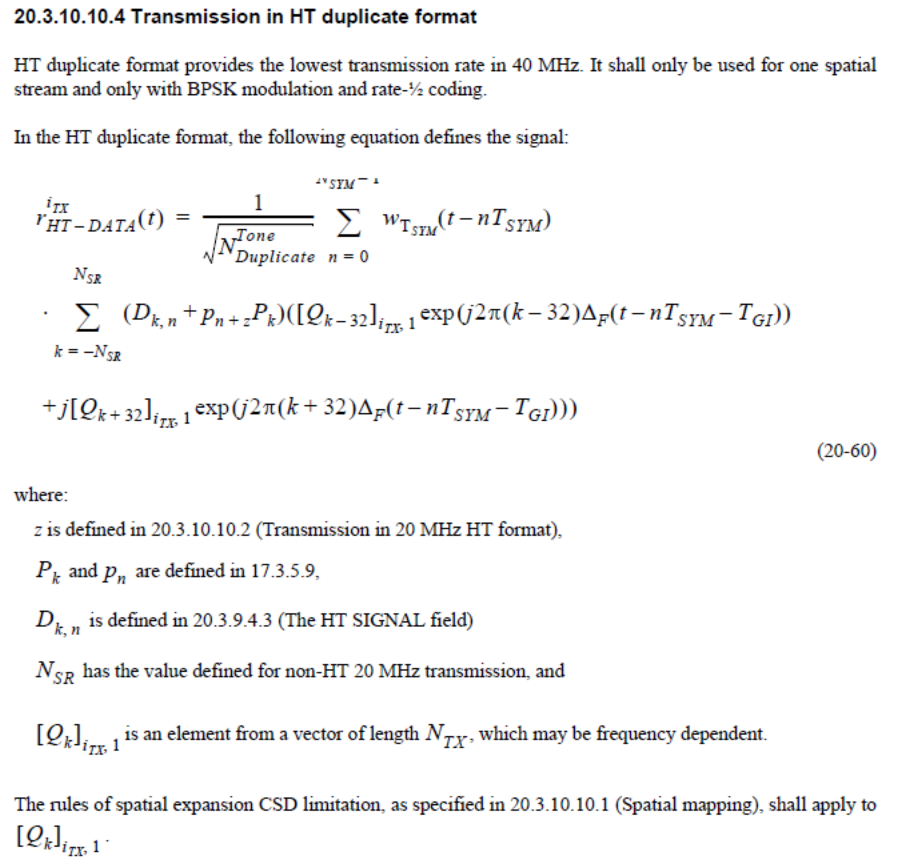
$$\cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX},i_{STS}} (\tilde{D}_k + p_{n+z}P^k_{(i_{STS},n)}) \Upsilon_k \exp(j2\pi k\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{STS}}))$$

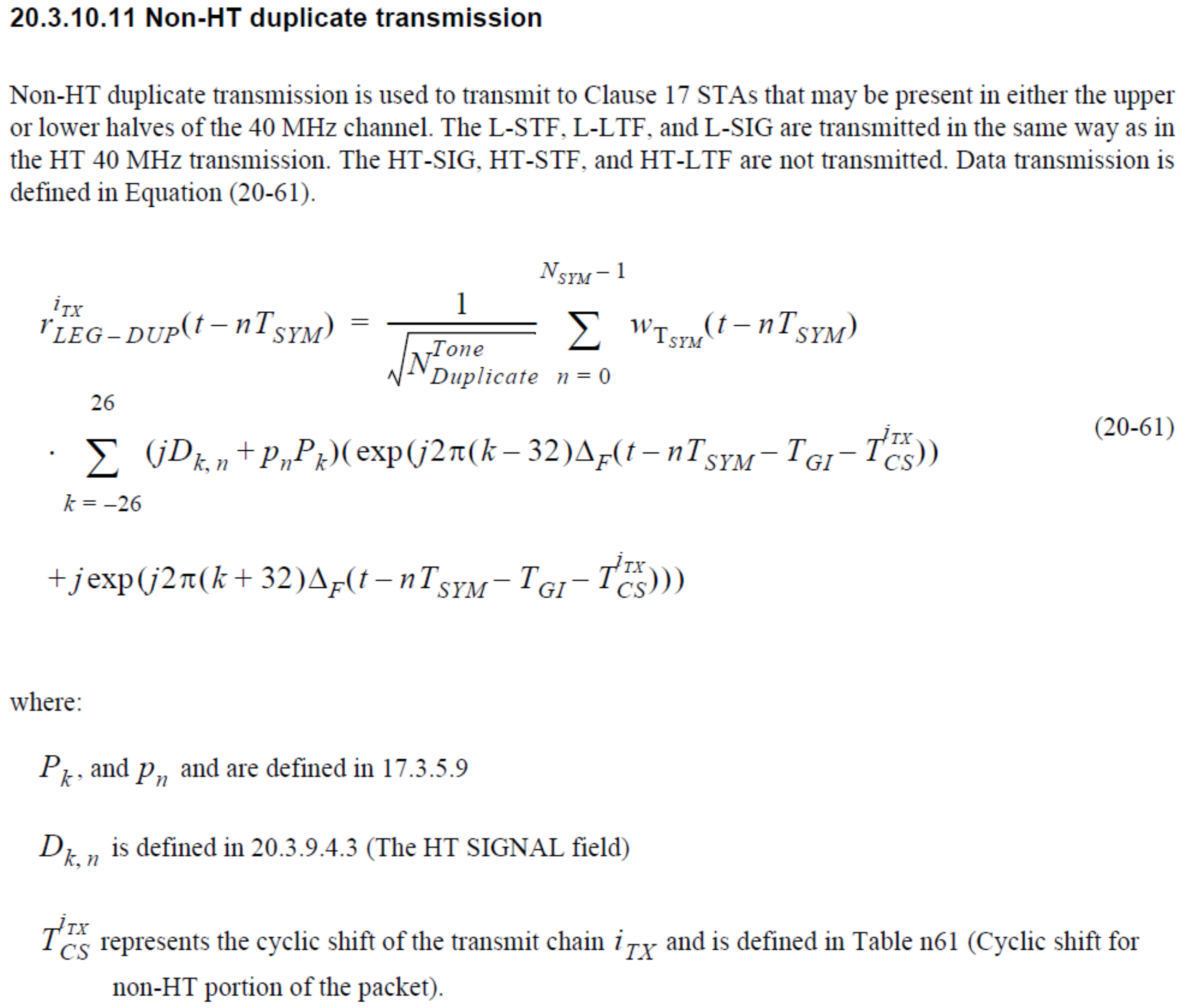
where

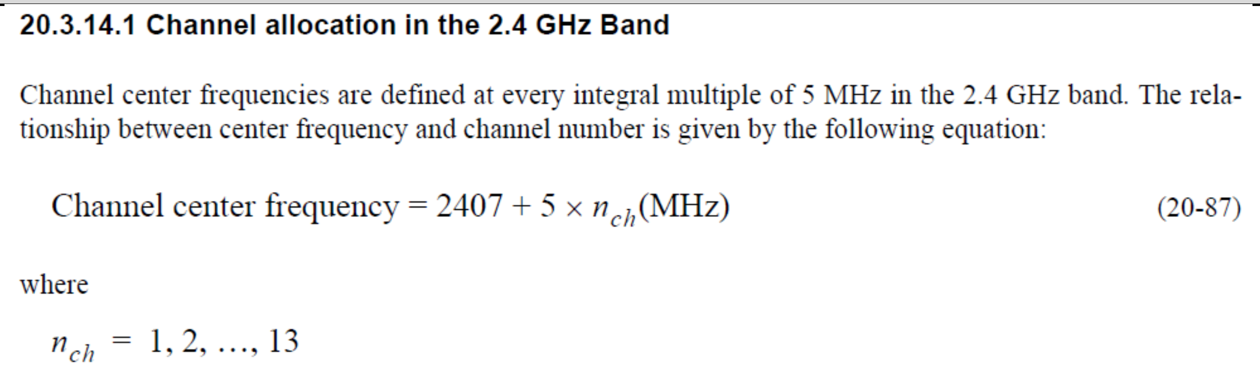
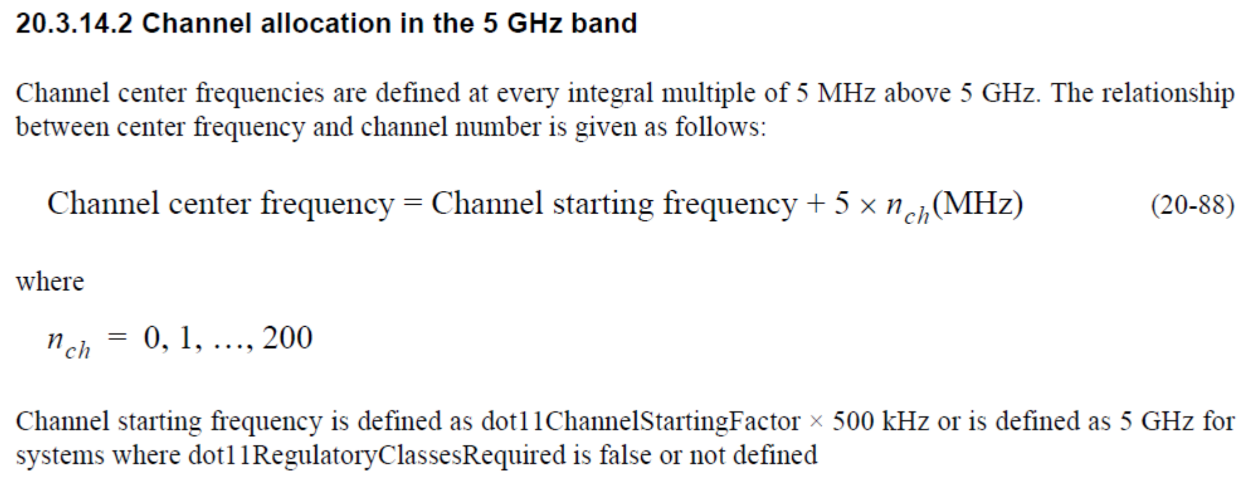
z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

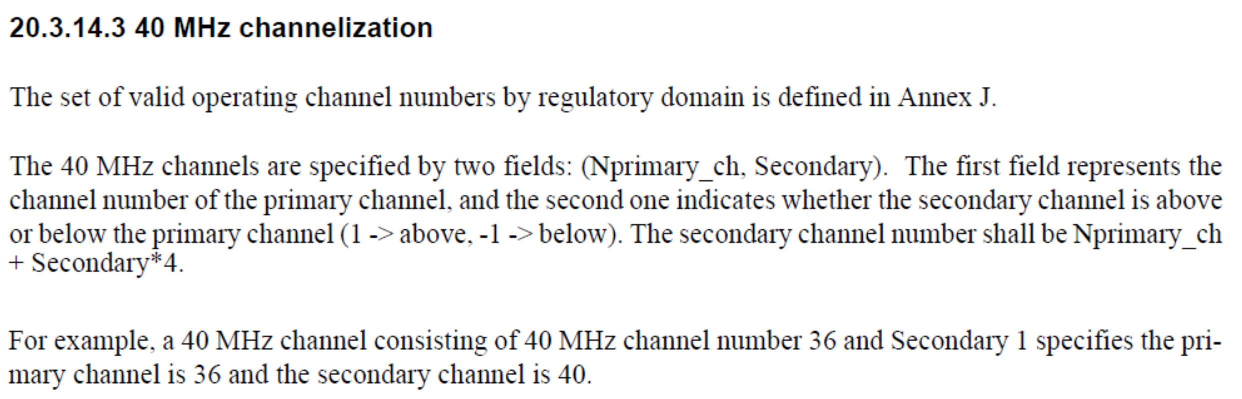
See, e.g., 802.11n D2.0 § 20.3.10.10.3

</td></tr>
</table>

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n} + p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t - nT_{SYM} - T_{GI})) + j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t - nT_{SYM} - T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r_{LEG-DUP}^{i_{TX}}(t-nT_{SYM}) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}}\sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26}(jD_{k,n}+p_nP_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{TX}})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{TX}})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T_{CS}^{i_{TX}}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz})$ (20-87) where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz})$ (20-88) where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

<table>
<tr><th>Claim 10 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>See, e.g., 802.11n D2.0 § 20.3.20.3

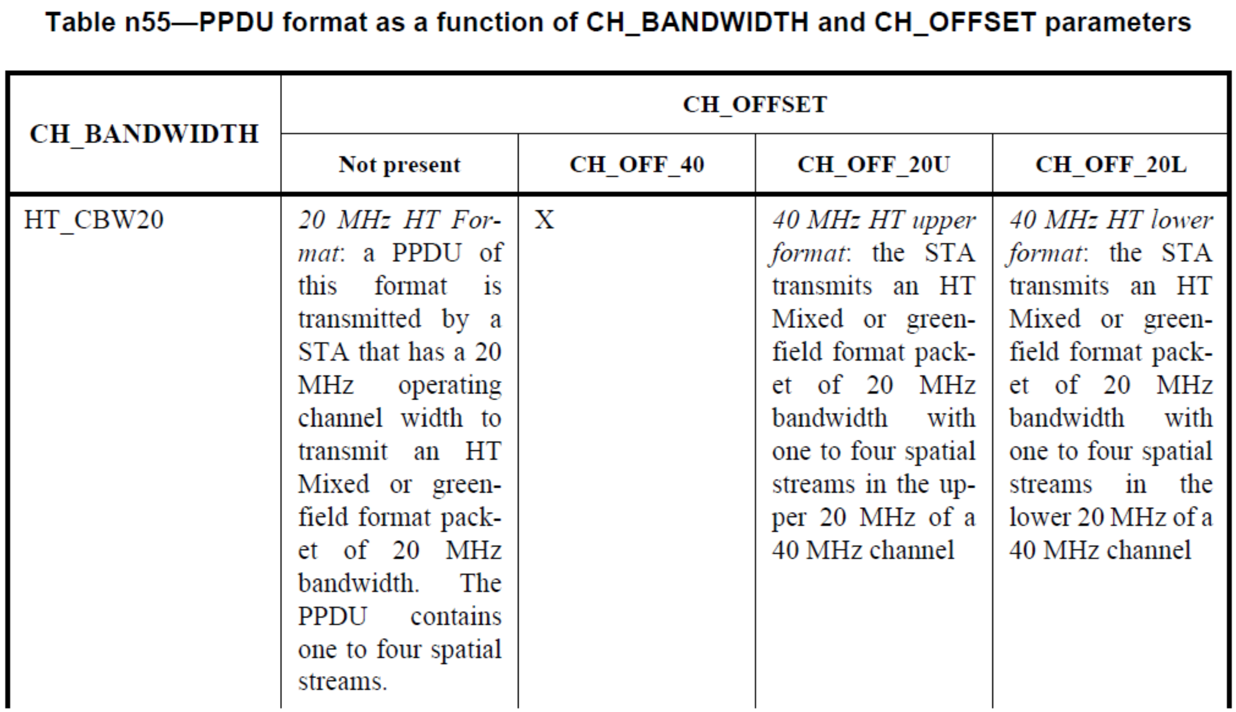
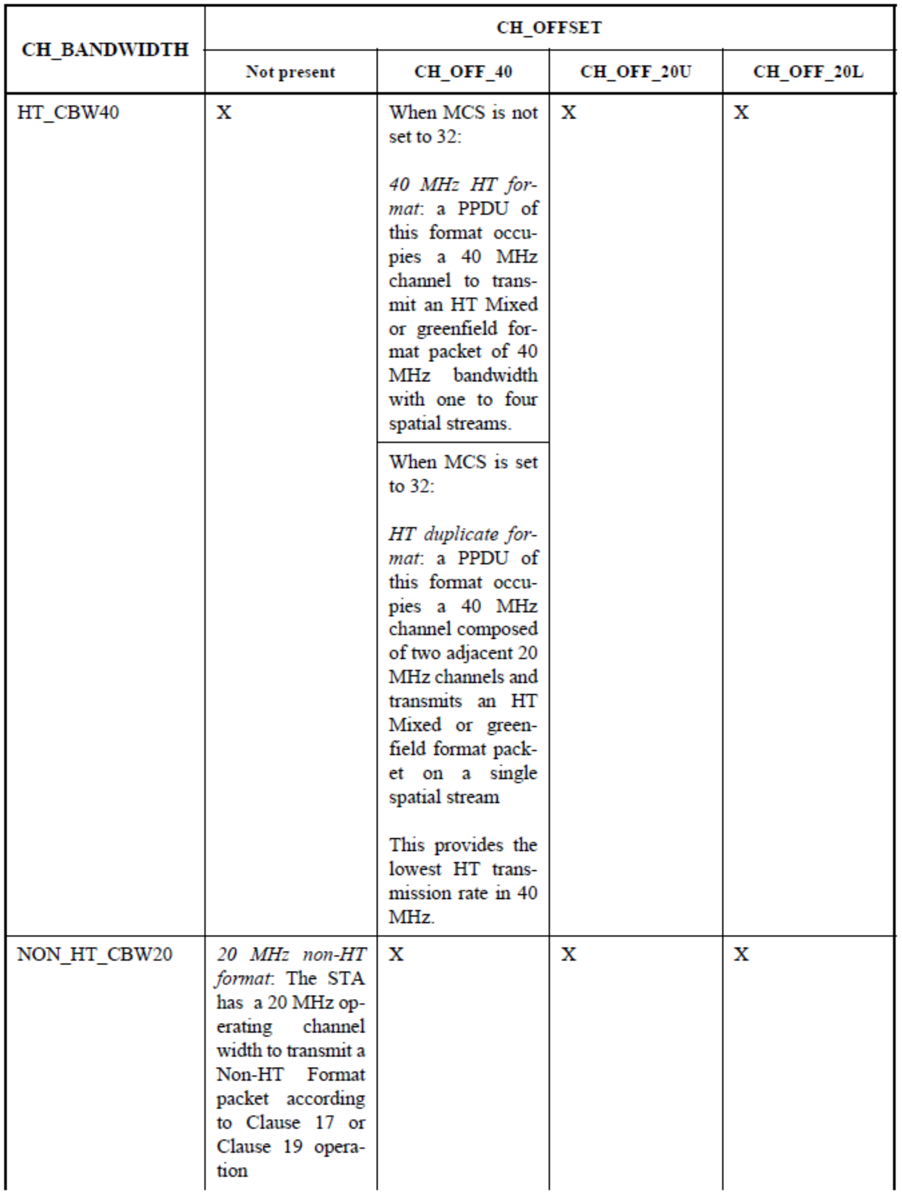
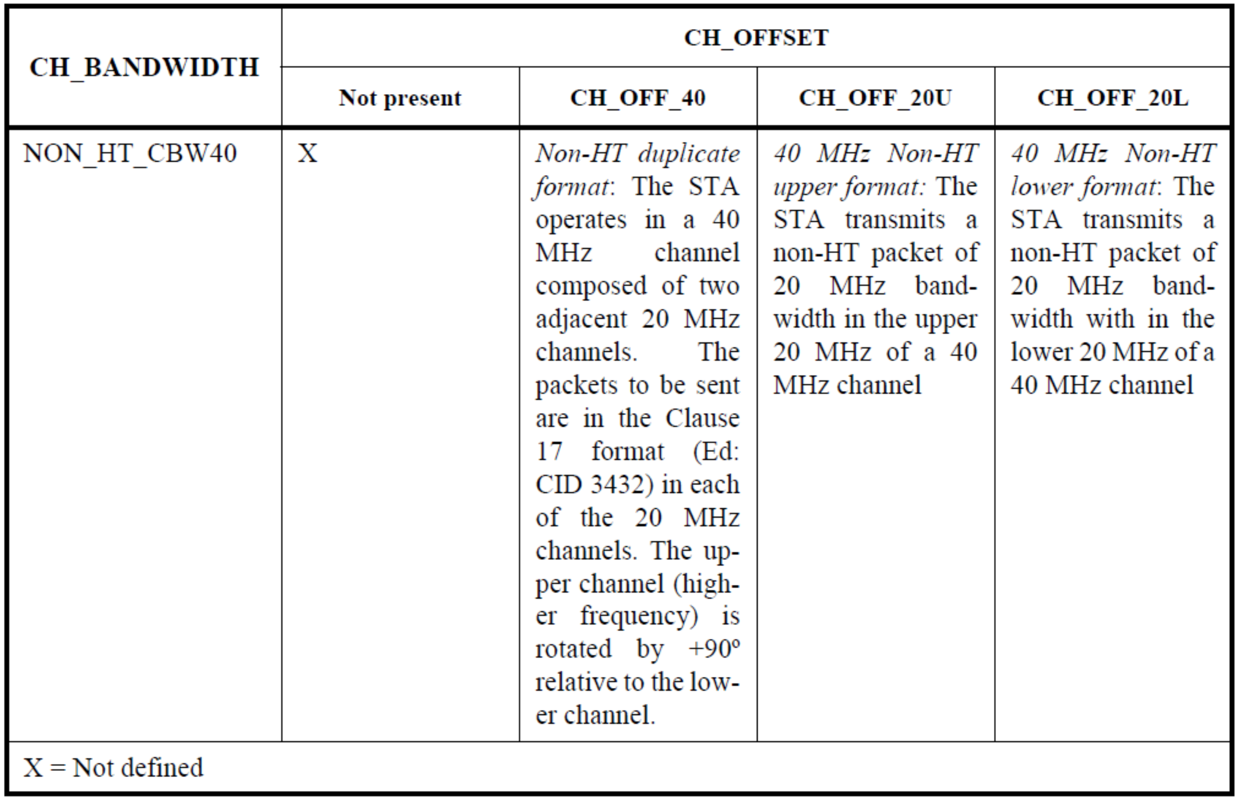



Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters
<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>HT_CBW20</td><td><i>20 MHz HT Format</i>: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.</td><td>X</td><td><i>40 MHz HT upper format</i>: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel</td><td><i>40 MHz HT lower format</i>: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel</td></tr>
</table>
</td></tr>
</table>



CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

<table>
<tr><th>Claim 10 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>NON_HT_CBW40</td><td>X</td><td><i>Non-HT duplicate format</i>: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.</td><td><i>40 MHz Non-HT upper format:</i> The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel</td><td><i>40 MHz Non-HT lower format</i>: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel</td></tr>
<tr><td colspan="5">X = Not defined</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n55
</td></tr>
</table>

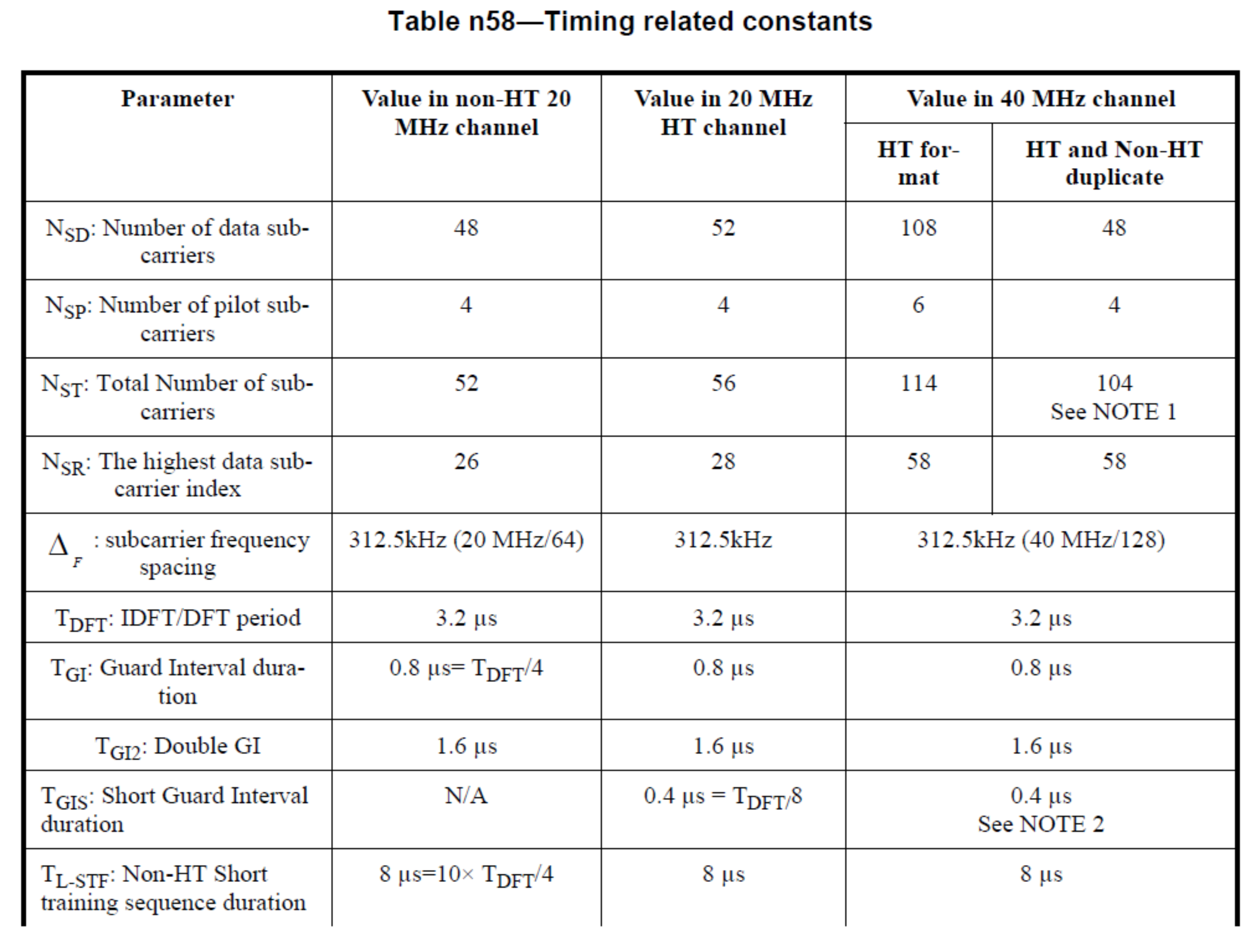
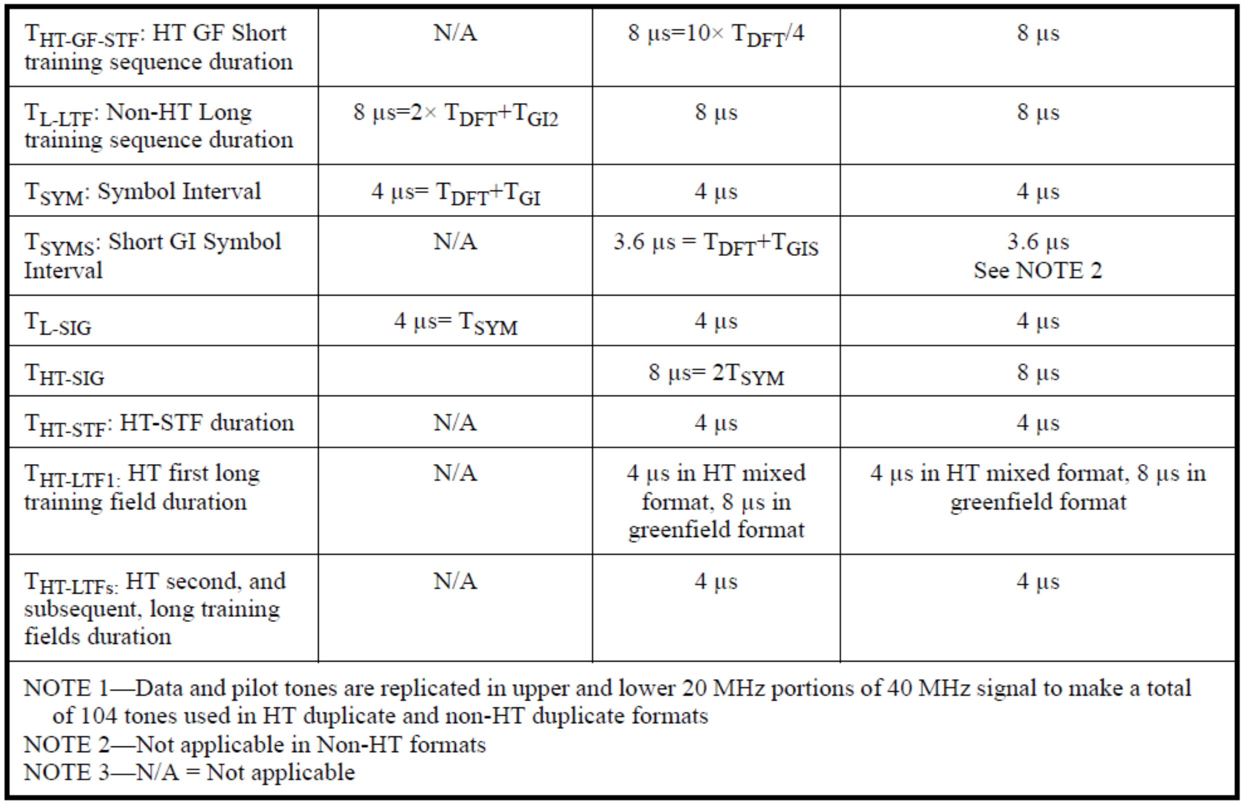
Claim 10 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	

Table n58—Timing related constants

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

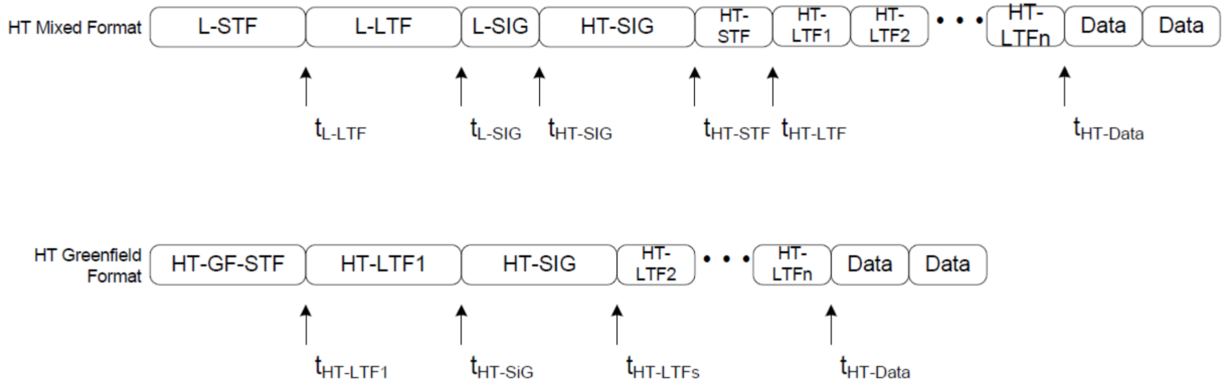
Claim 10 of the '802 Patent	**Prior Art Reference – 802.11n D2.0**



$T_{\text{HT-GF-STF}}$: HT GF Short training sequence duration	N/A	8 µs=10× T_{DFT}/4	8 µs
$T_{\text{L-LTF}}$: Non-HT Long training sequence duration	8 µs=2× T_{DFT}+T_{GI2}	8 µs	8 µs
T_{SYM}: Symbol Interval	4 µs= T_{DFT}+T_{GI}	4 µs	4 µs
T_{SYMS}: Short GI Symbol Interval	N/A	3.6 µs = T_{DFT}+T_{GIS}	3.6 µs See NOTE 2
$T_{\text{L-SIG}}$	4 µs= T_{SYM}	4 µs	4 µs
$T_{\text{HT-SIG}}$		8 µs= 2T_{SYM}	8 µs
$T_{\text{HT-STF}}$: HT-STF duration	N/A	4 µs	4 µs
$T_{\text{HT-LTF1}}$: HT first long training field duration	N/A	4 µs in HT mixed format, 8 µs in greenfield format	4 µs in HT mixed format, 8 µs in greenfield format
$T_{\text{HT-LTFs}}$: HT second, and subsequent, long training fields duration	N/A	4 µs	4 µs

NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable

See, e.g., 802.11n D2.0 Table n58

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.
[10.11] wherein the bandwidth of said power amplifier is greater than the difference between a lowest frequency in the first up-converted frequency range and a highest frequency in the	802.11n D2.0 discloses “wherein the bandwidth of said power amplifier is greater than the difference between a lowest frequency in the first up-converted frequency range and a highest frequency in the second up-converted frequency range.” See, e.g.: **high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
second up-converted frequency range.	**non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0

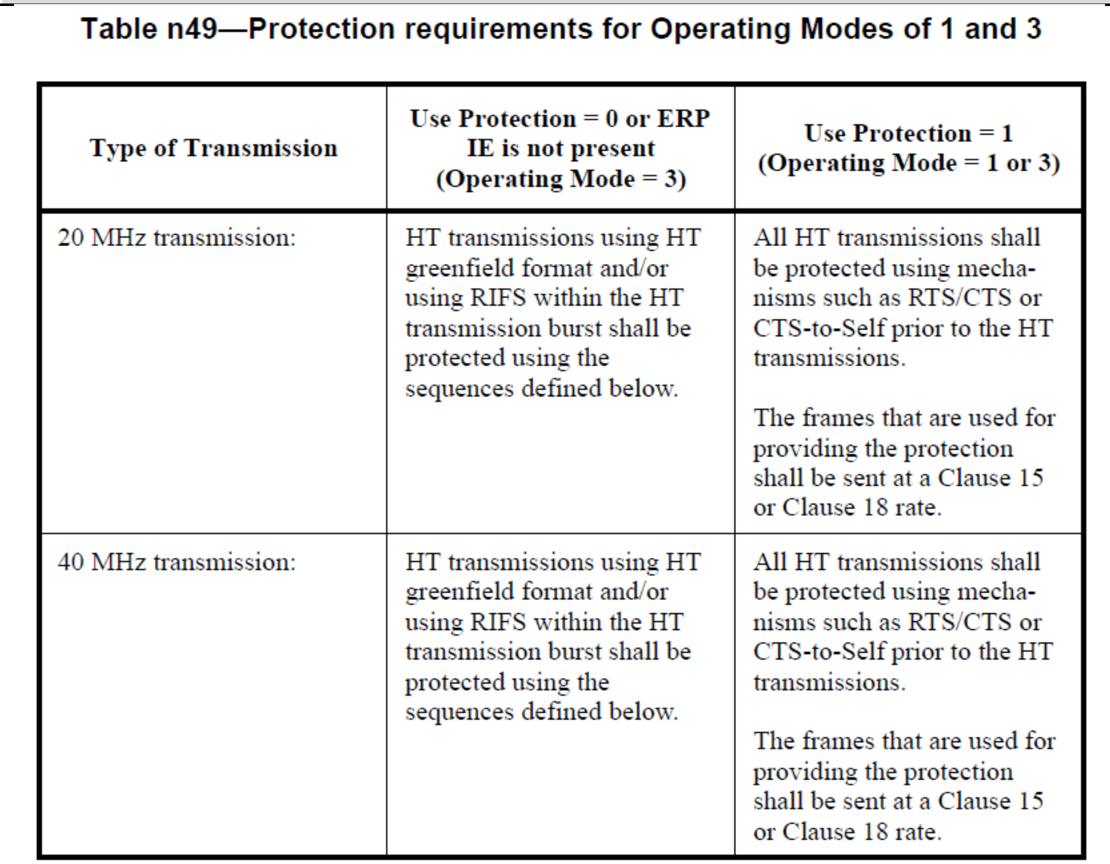
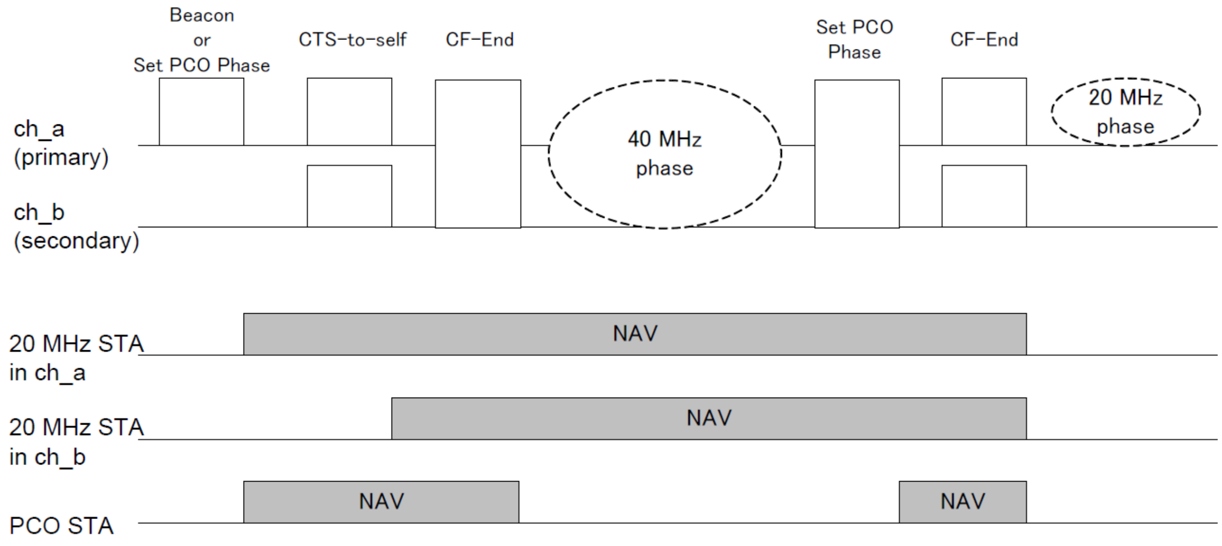


Table n49—Protection requirements for Operating Modes of 1 and 3

Type of Transmission	Use Protection = 0 or ERP IE is not present (Operating Mode = 3)	Use Protection = 1 (Operating Mode = 1 or 3)
20 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.
40 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.
NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

Claim 10 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\left\{ r(t) \exp\left(j 2\pi f_c t \right) \right\}$ (20-1) where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

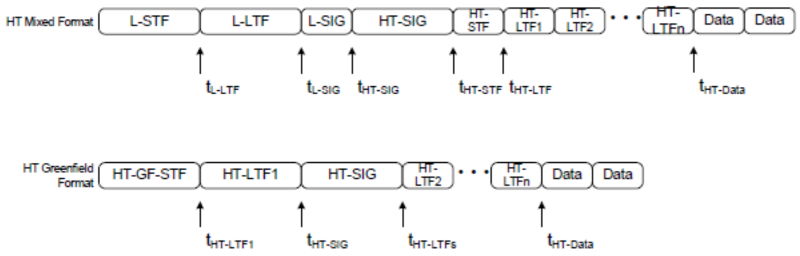


Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) \;=\; & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - (i_{LTF}-1)T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \tag{20-2}$$

where

$$t_{L-LTF} = T_{L-STF}$$

$$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$$

$$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$$

$$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1}) \\ & + r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2)T_{HT-LTFs}) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \quad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\text{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

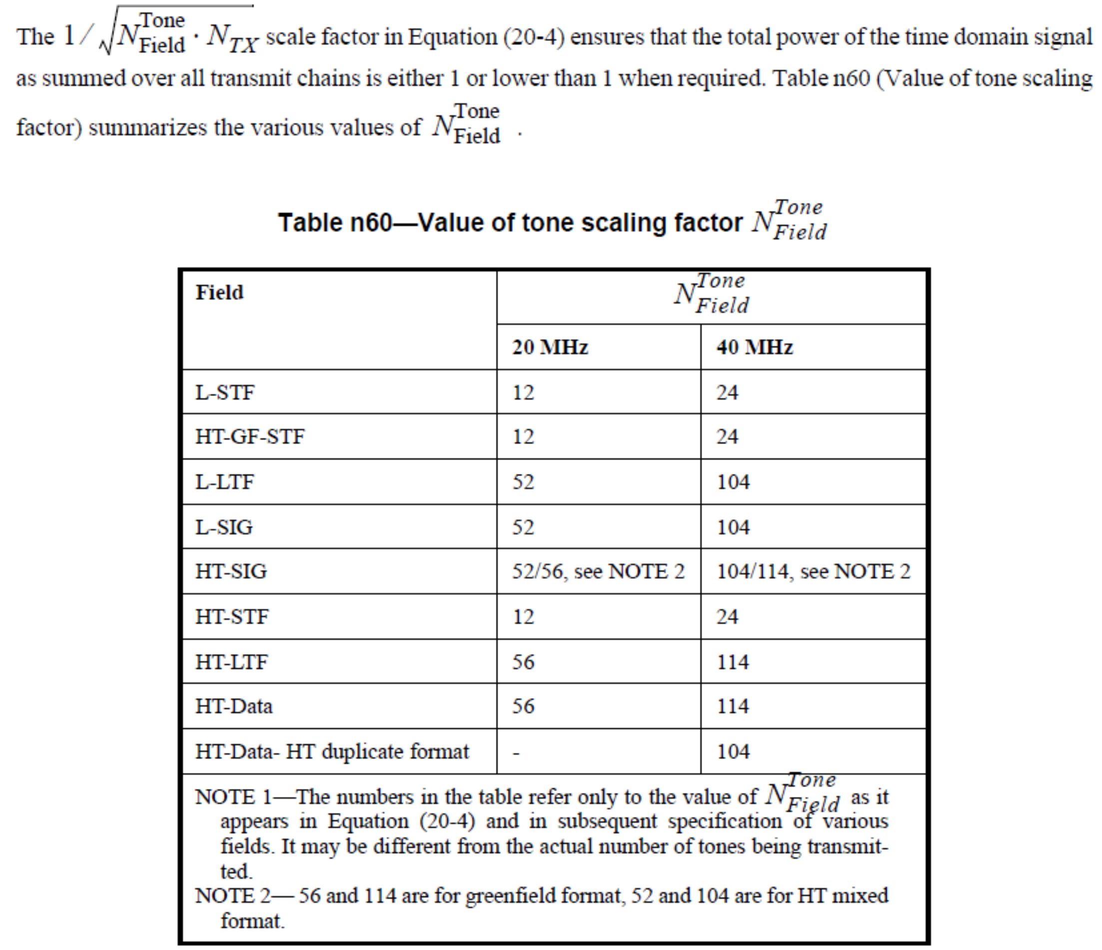
$$r_{\text{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j 2 \pi k \Delta_F t) \quad (20\text{-}4)$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \quad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \quad (20\text{-}6)$$

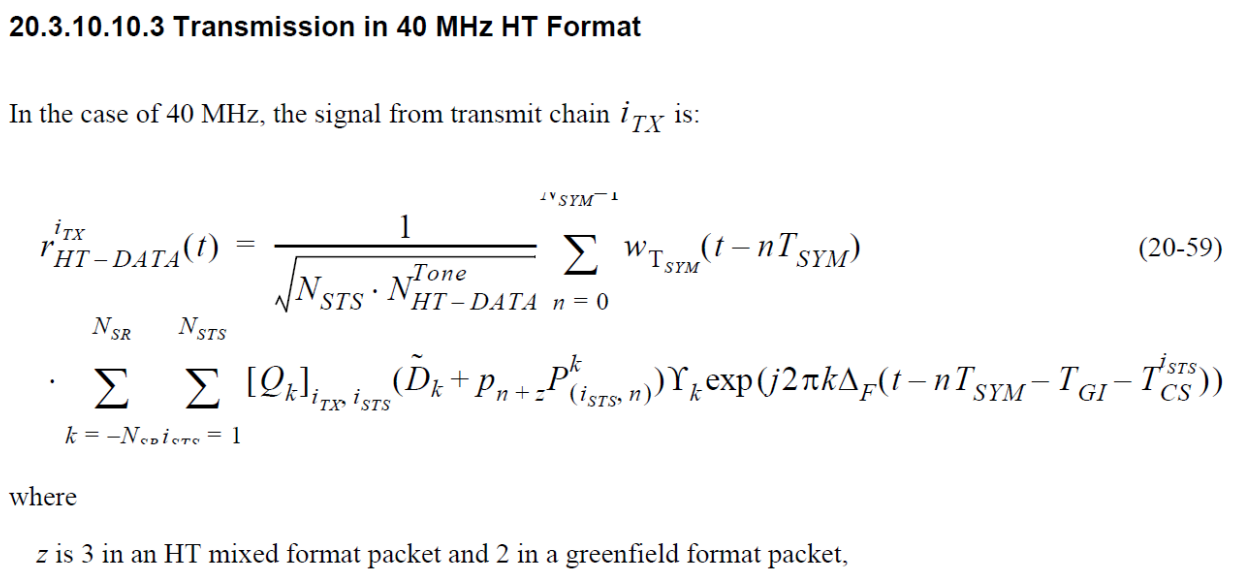
Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$. **Table n60—Value of tone scaling factor N_{Field}^{Tone}** See table below. See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65 **20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel** When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

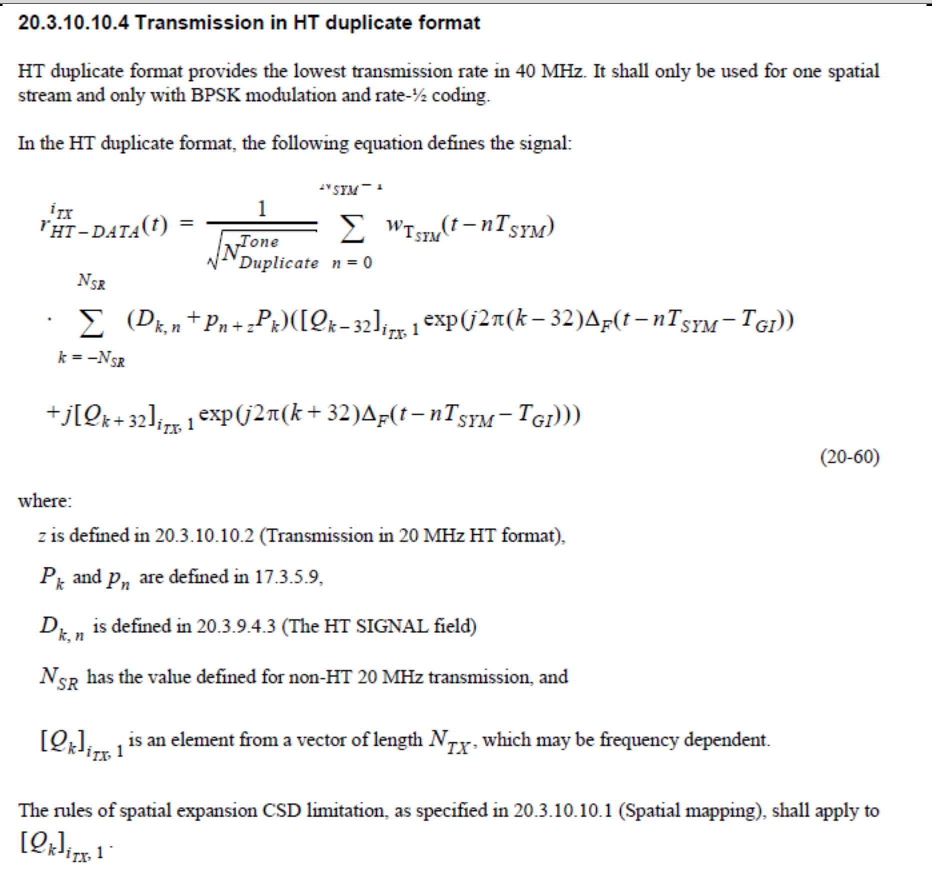
Field	N_{Field}^{Tone}	
	20 MHz	40 MHz
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

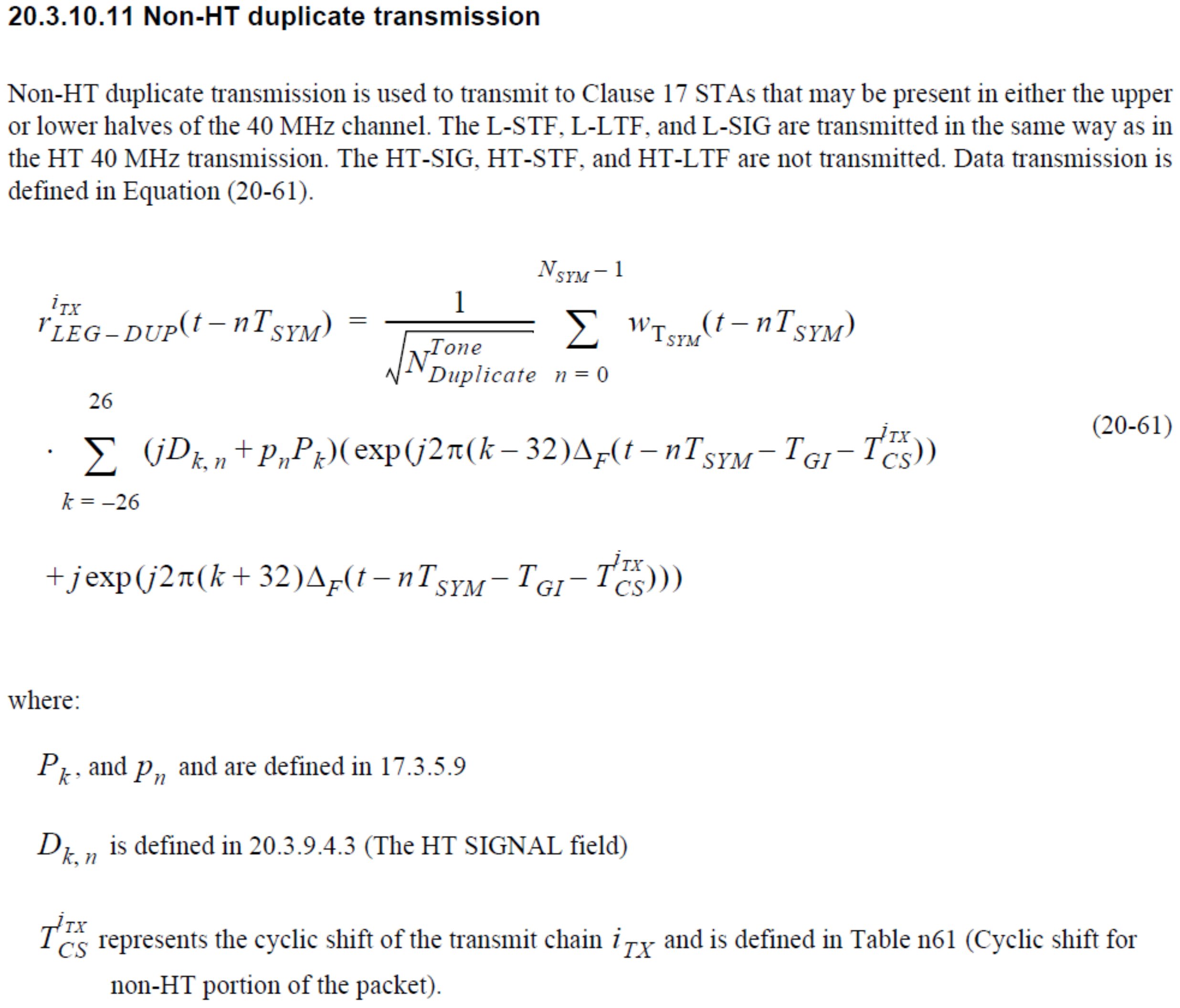
NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

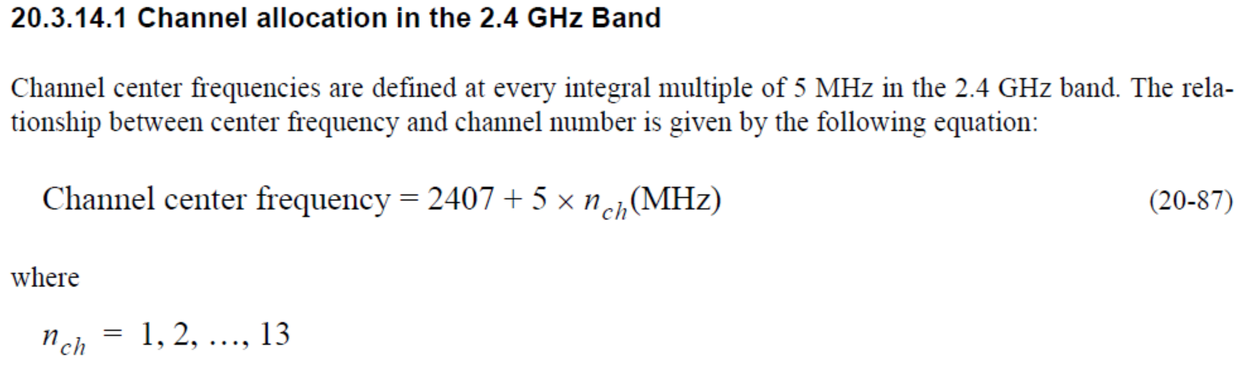
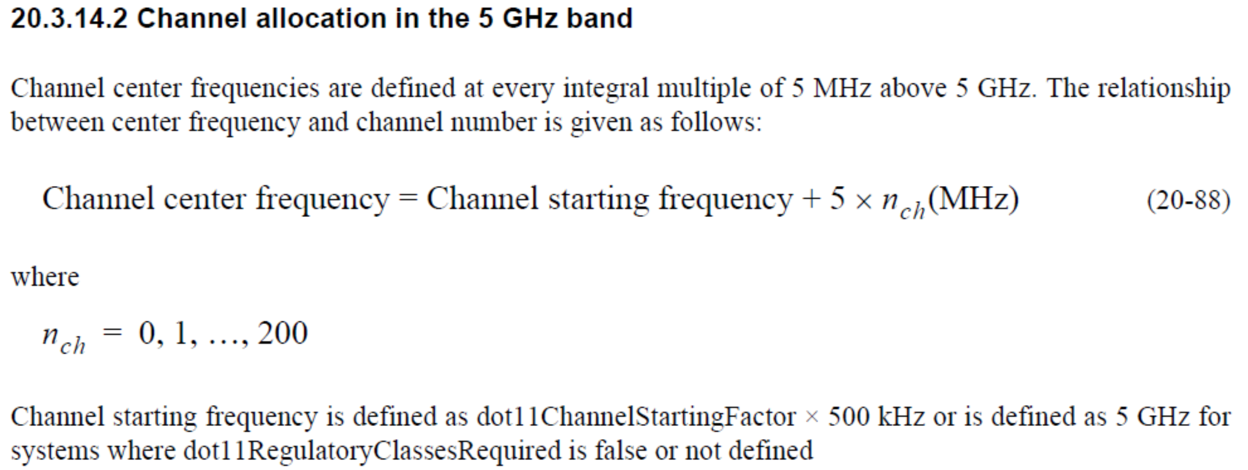
NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

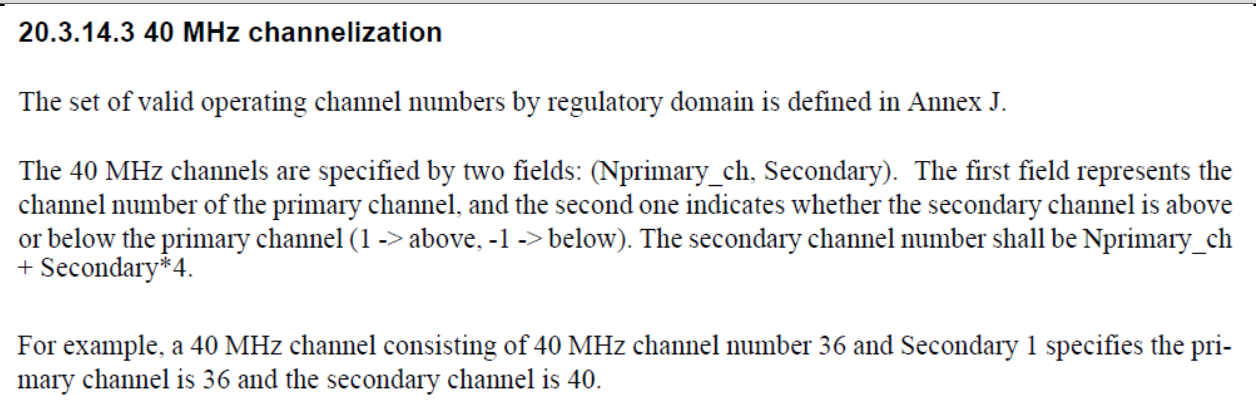
Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $$D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $$r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P_{(i_{STS},n)}^{k}) \exp(j 2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}})) \quad (20\text{-}58)$$ where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P_{(i_{STS}, n)}^{k}) \Upsilon_k \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (20-59) where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

Claim 10 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n} + p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t - nT_{SYM} - T_{GI})) + j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t - nT_{SYM} - T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

Claim 10 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r^{i_{TX}}_{LEG-DUP}(t-nT_{SYM}) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n}+p_nP_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T^{i_{TX}}_{CS}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 10 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz}) \quad (20\text{-}87)$ where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz}) \quad (20\text{-}88)$ where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

<table>
<tr><th>Claim 10 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>See, e.g., 802.11n D2.0 § 20.3.20.3

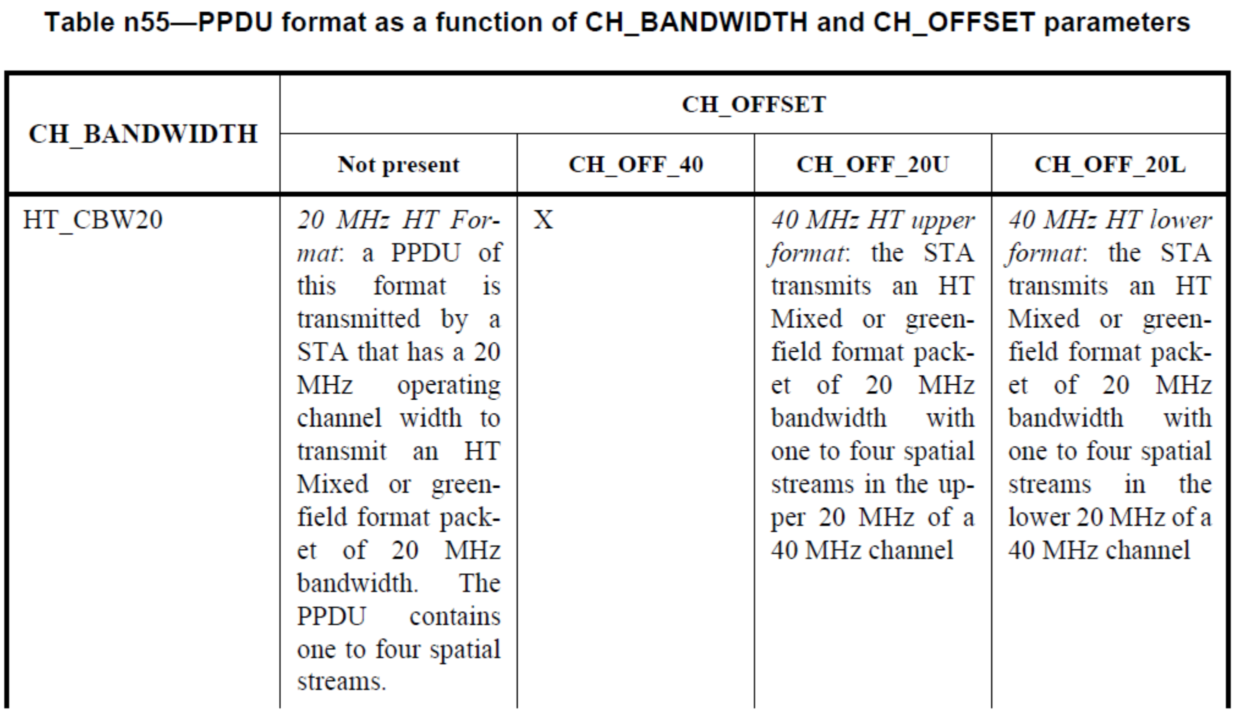
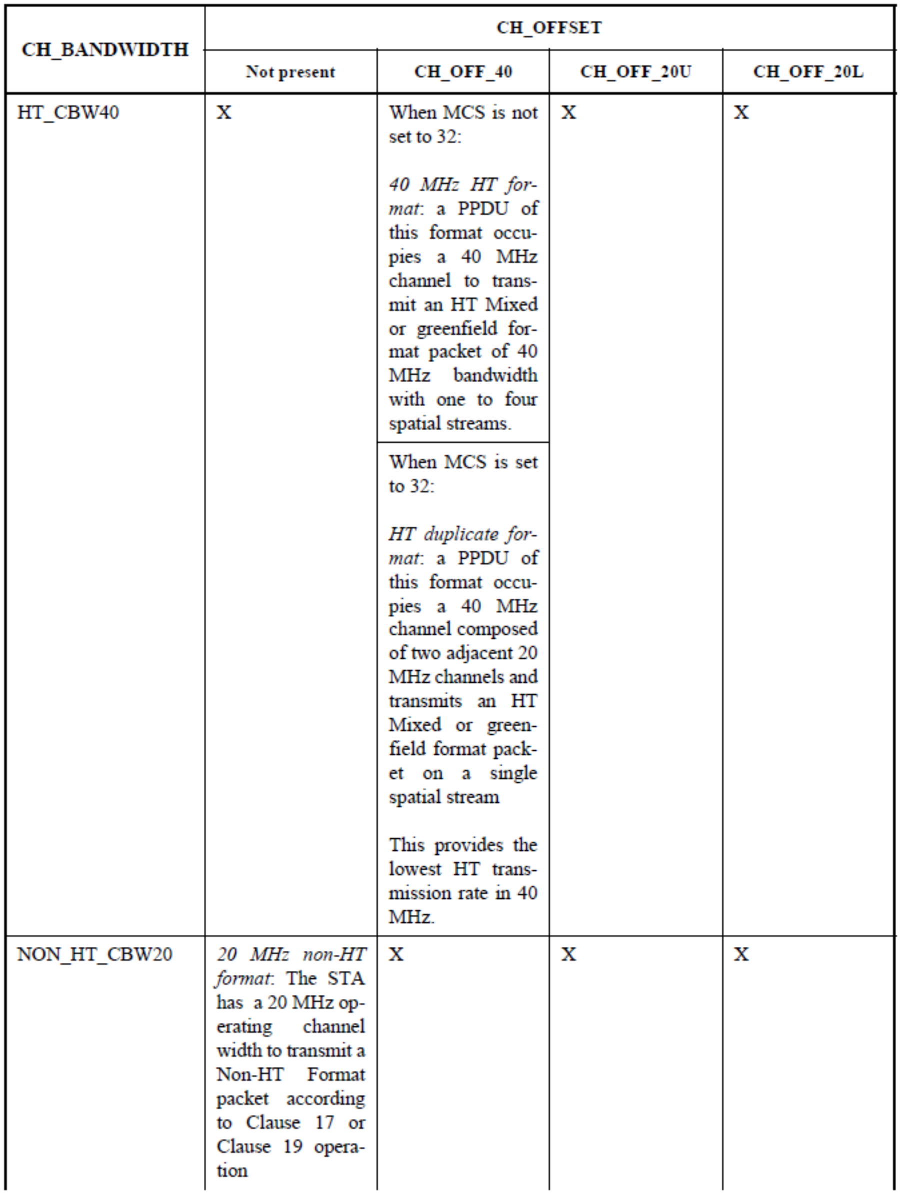


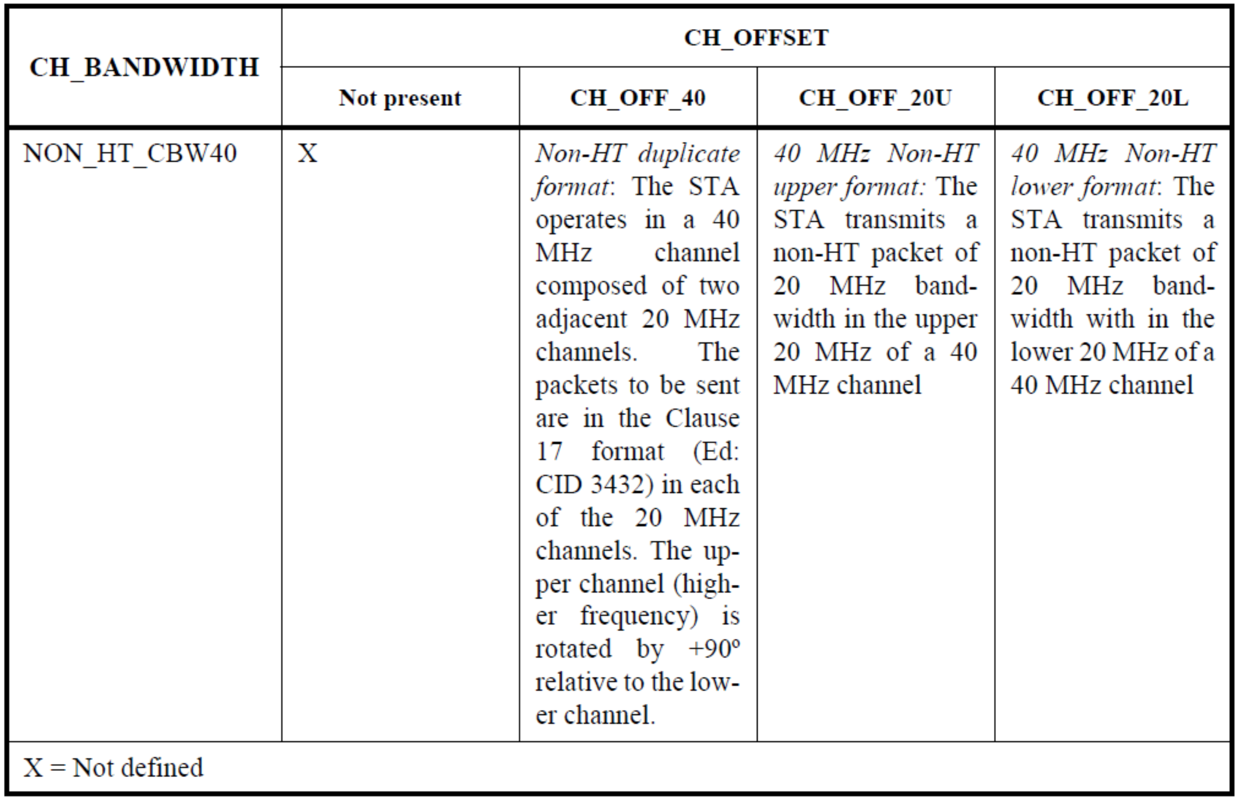
Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>HT_CBW20</td><td><i>20 MHz HT Format</i>: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.</td><td>X</td><td><i>40 MHz HT upper format</i>: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel</td><td><i>40 MHz HT lower format</i>: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel</td></tr>
</table>
</td></tr>
</table>



CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

Claim 10 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**



CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
NON_HT_CBW40	X	*Non-HT duplicate format*: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.	*40 MHz Non-HT upper format:* The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel	*40 MHz Non-HT lower format*: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel
X = Not defined				

See, e.g., 802.11n D2.0 Table n55

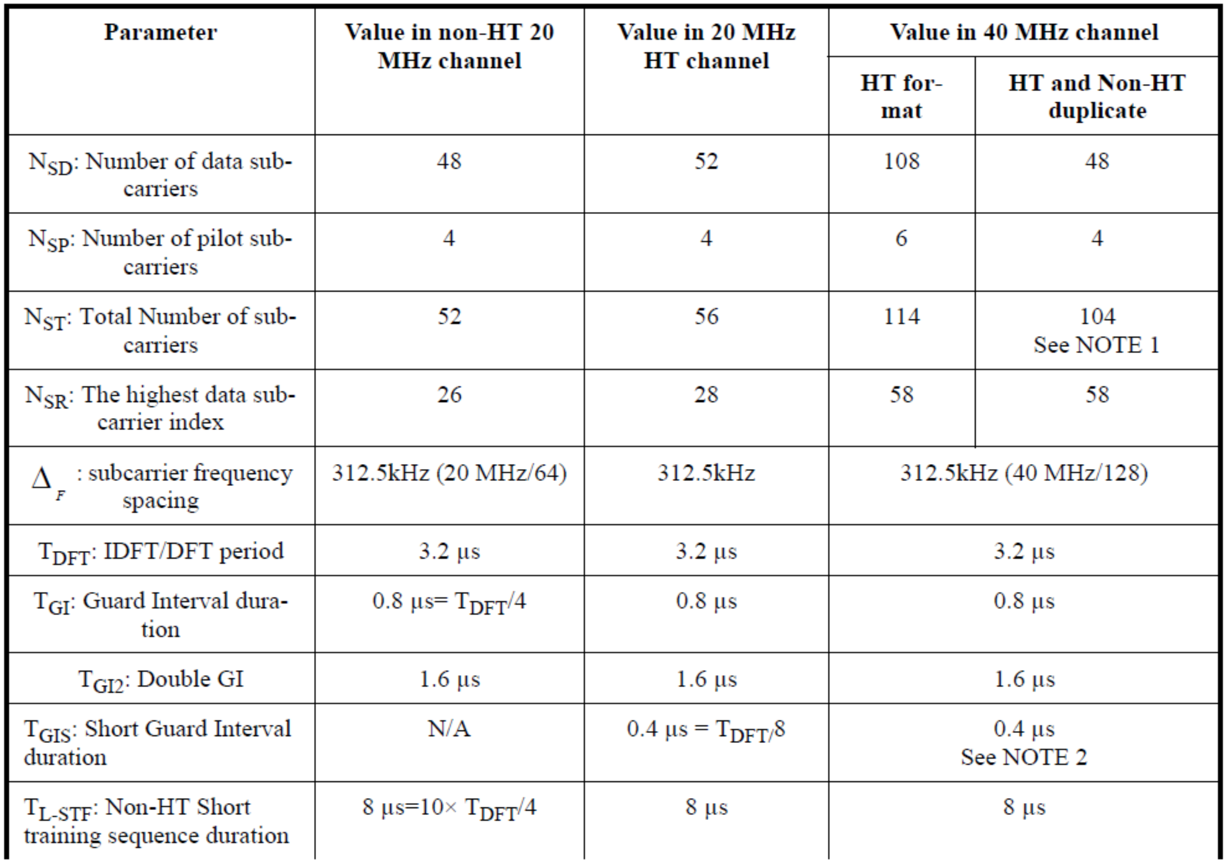
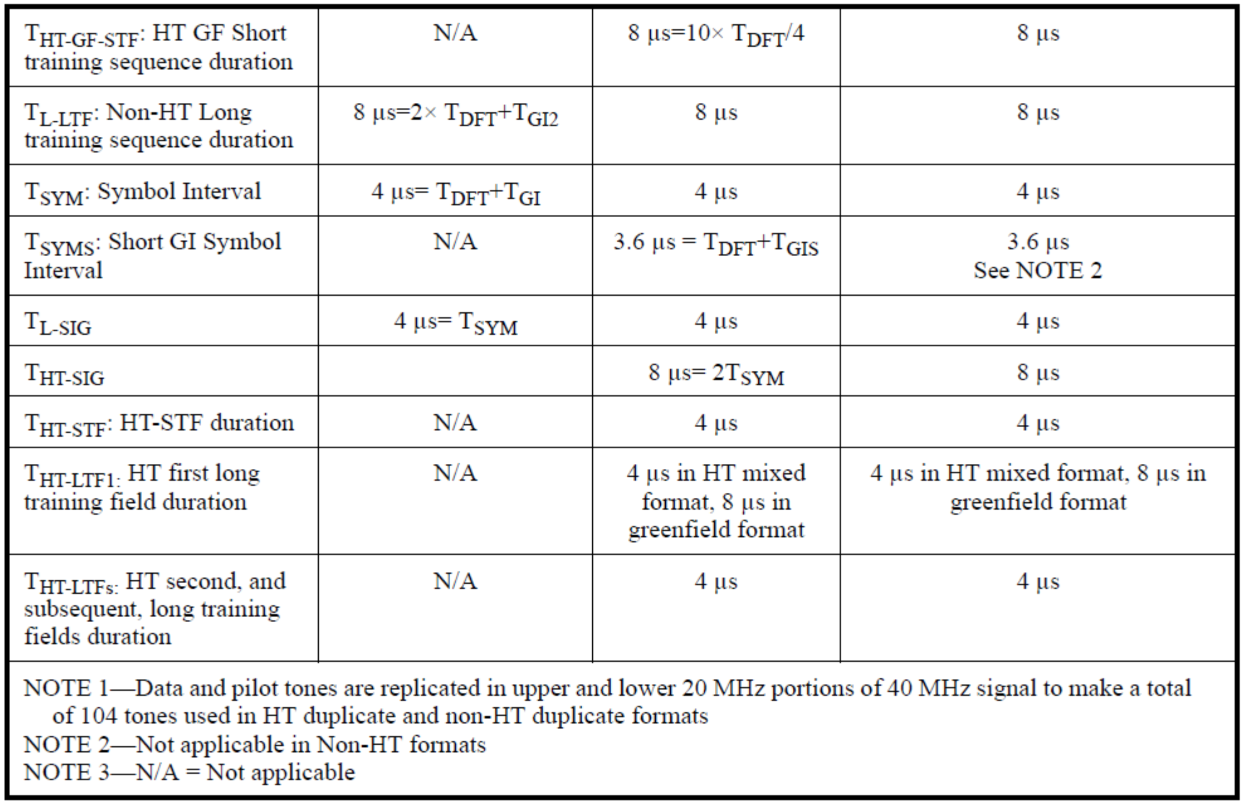
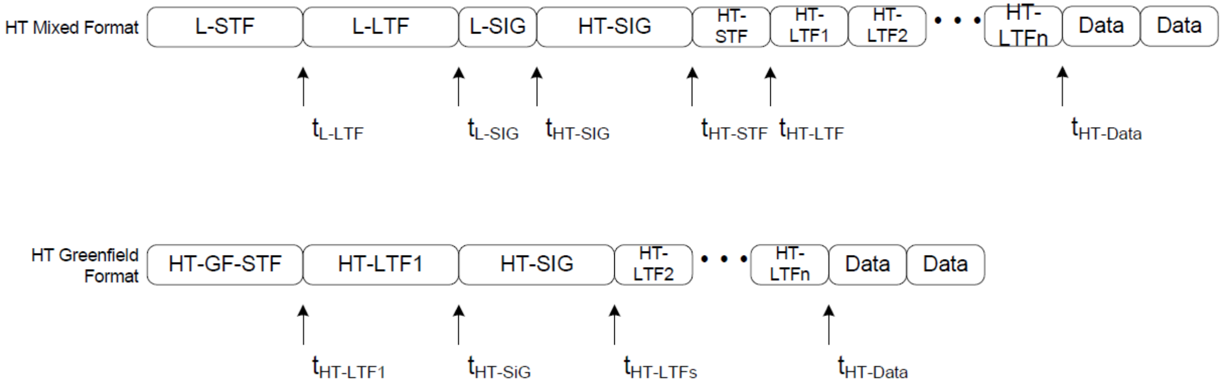
Claim 10 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	

Table n58—Timing related constants

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F: subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

<table>
<tr><th>Claim 10 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><td>$T_{HT\text{-}GF\text{-}STF}$: HT GF Short training sequence duration</td><td>N/A</td><td>8 μs=10× $T_{DFT}/4$</td><td>8 μs</td></tr>
<tr><td>$T_{L\text{-}LTF}$: Non-HT Long training sequence duration</td><td>8 μs=2× $T_{DFT}+T_{GI2}$</td><td>8 μs</td><td>8 μs</td></tr>
<tr><td>T_{SYM}: Symbol Interval</td><td>4 μs= $T_{DFT}+T_{GI}$</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td>T_{SYMS}: Short GI Symbol Interval</td><td>N/A</td><td>3.6 μs = $T_{DFT}+T_{GIS}$</td><td>3.6 μs
See NOTE 2</td></tr>
<tr><td>$T_{L\text{-}SIG}$</td><td>4 μs= T_{SYM}</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td>$T_{HT\text{-}SIG}$</td><td></td><td>8 μs= $2T_{SYM}$</td><td>8 μs</td></tr>
<tr><td>$T_{HT\text{-}STF}$: HT-STF duration</td><td>N/A</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td>$T_{HT\text{-}LTF1}$: HT first long training field duration</td><td>N/A</td><td>4 μs in HT mixed format, 8 μs in greenfield format</td><td>4 μs in HT mixed format, 8 μs in greenfield format</td></tr>
<tr><td>$T_{HT\text{-}LTFs}$: HT second, and subsequent, long training fields duration</td><td>N/A</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td colspan="4">NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n58
</td></tr>
</table>

Claim 10 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.

Claim 13 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
[13.1] The method of claim 10	802.11n D2.0 discloses all the elements of claim 10 for all the reasons provided above.
[13.2] wherein the first digital signal is encoded using a first wireless protocol and the	802.11n D2.0 discloses “wherein the first digital signal is encoded using a first wireless protocol and the second digital signal is encoded using a second wireless protocol.” See, e.g.:

Claim 13 of the '802 Patent	Prior Art Reference – 802.11n D2.0
second digital signal is encoded using a second wireless protocol.	**high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19 **non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

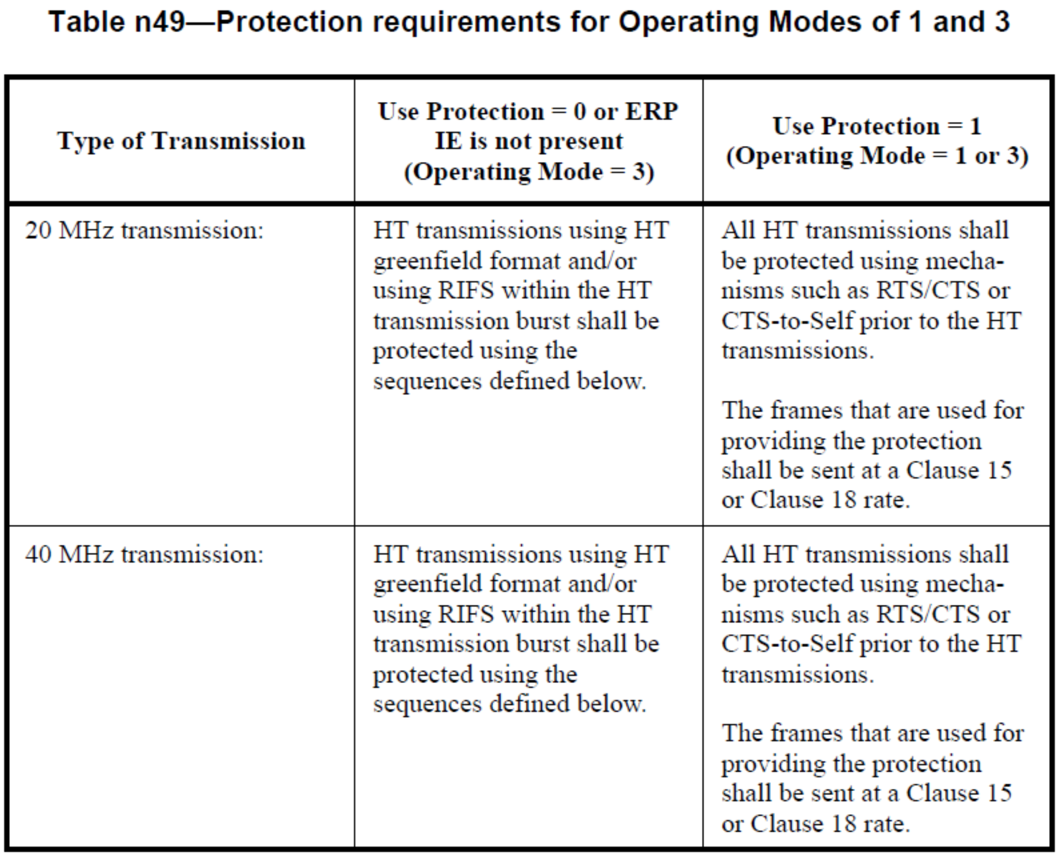
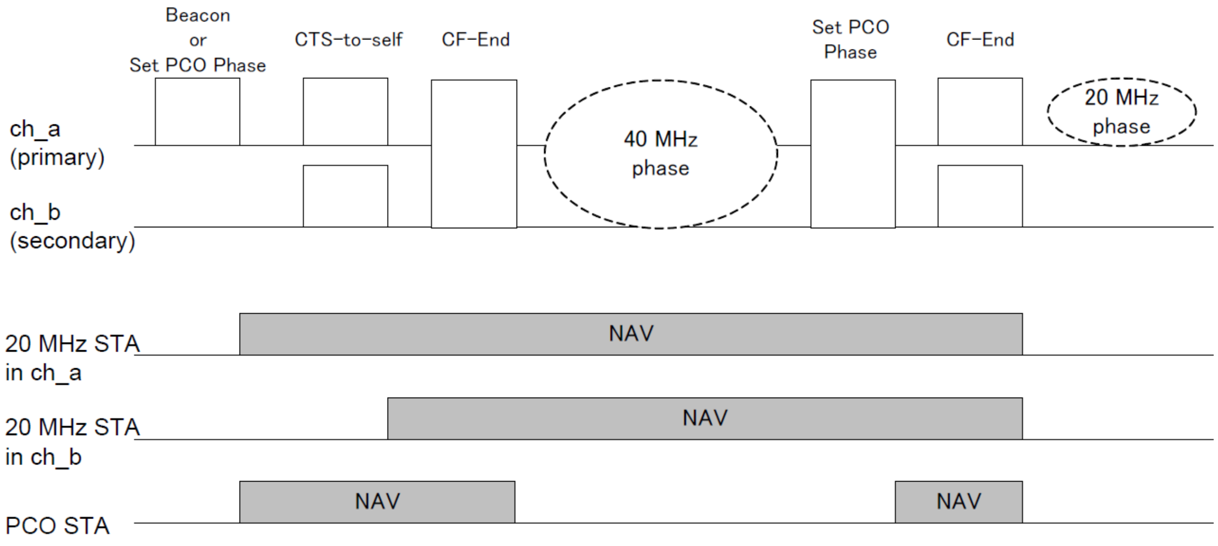
<table>
<tr><th>Claim 13 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>


Table n49—Protection requirements for Operating Modes of 1 and 3

<table>
<tr><th>Type of Transmission</th><th>Use Protection = 0 or ERP IE is not present (Operating Mode = 3)</th><th>Use Protection = 1 (Operating Mode = 1 or 3)</th></tr>
<tr><td>20 MHz transmission:</td><td>HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.</td><td>All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions.
The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.</td></tr>
<tr><td>40 MHz transmission:</td><td>HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.</td><td>All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions.
The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.</td></tr>
</table>

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.
NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).
</td></tr>
</table>

Claim 13 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

Claim 13 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

Claim 13 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 13 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

Claim 13 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

Claim 13 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

Claim 13 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\left\{ r(t) \exp\left(j2\pi f_c t \right) \right\} \quad (20\text{-}1)$ where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

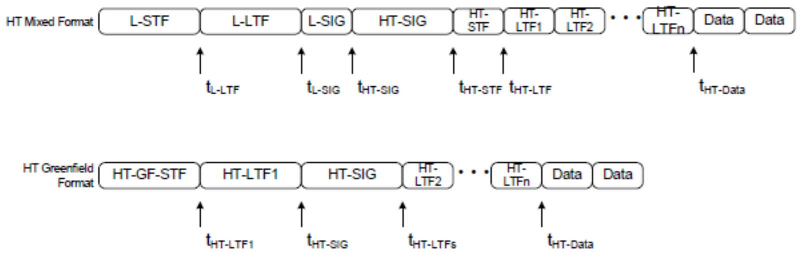


Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right)T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \qquad (20\text{-}2)$$

where

$t_{L-LTF} = T_{L-STF}$

$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$

$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$

$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1}) \\ & + r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2) T_{HT-LTFs}) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \quad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\mathrm{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\mathrm{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\mathrm{Field}}^{\mathrm{Tone}} \cdot N_{TX}}} w_{T_{\mathrm{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j 2\pi k \Delta_F t) \quad (20\text{-}4)$$

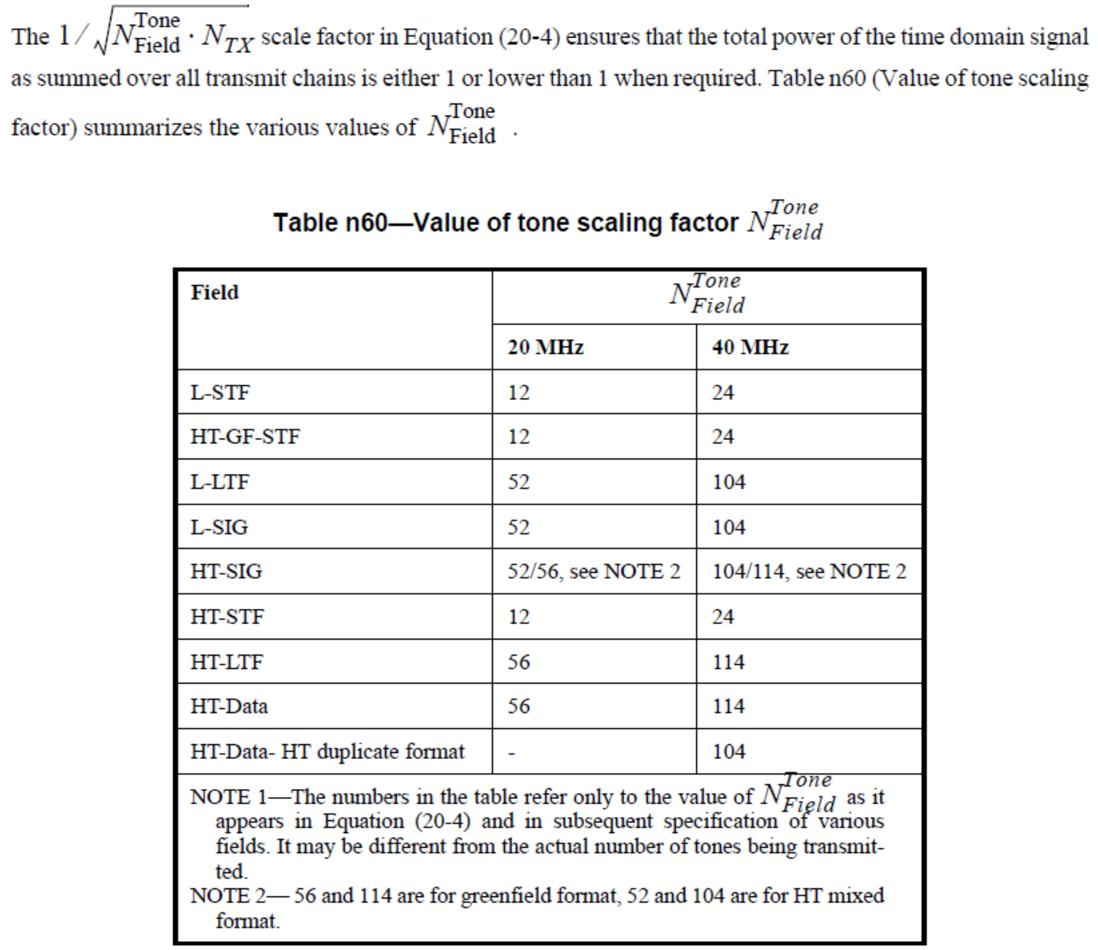
This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\mathrm{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \quad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \quad (20\text{-}6)$$

Claim 13 of the ’802 Patent	Prior Art Reference – 802.11n D2.0



The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

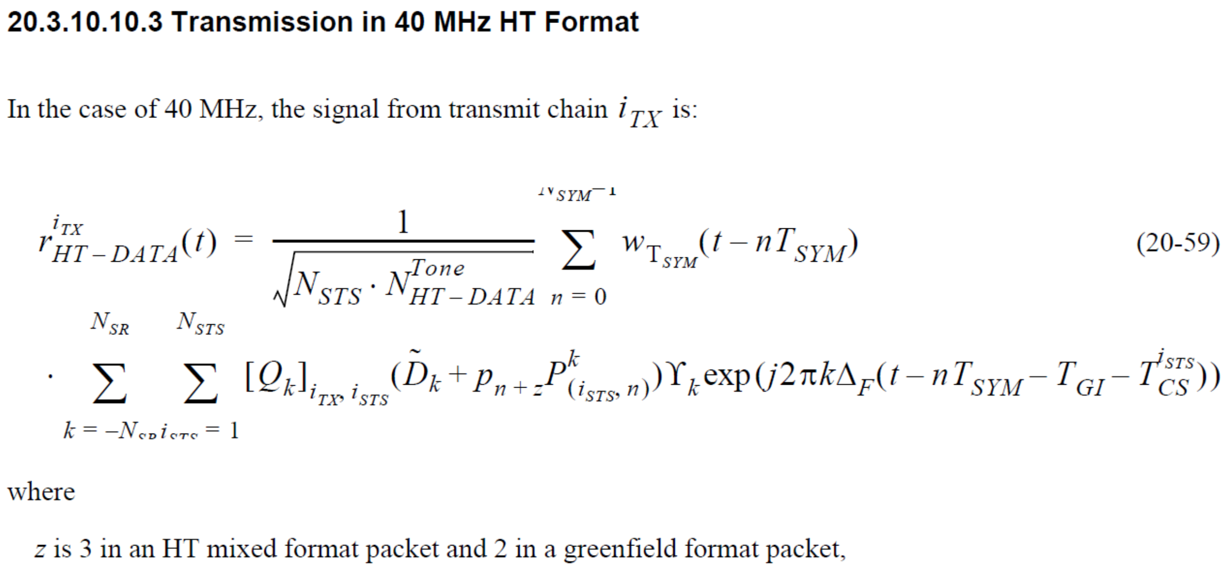
Field	N_{Field}^{Tone}	
	20 MHz	**40 MHz**
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104
NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted. NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.		

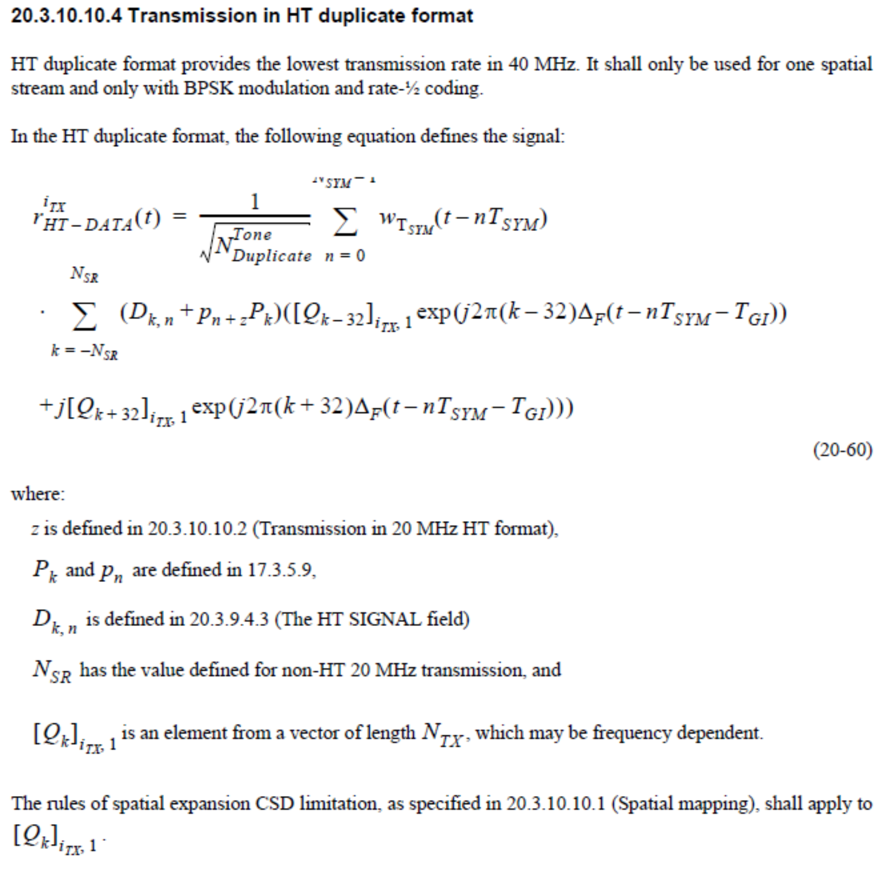
See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

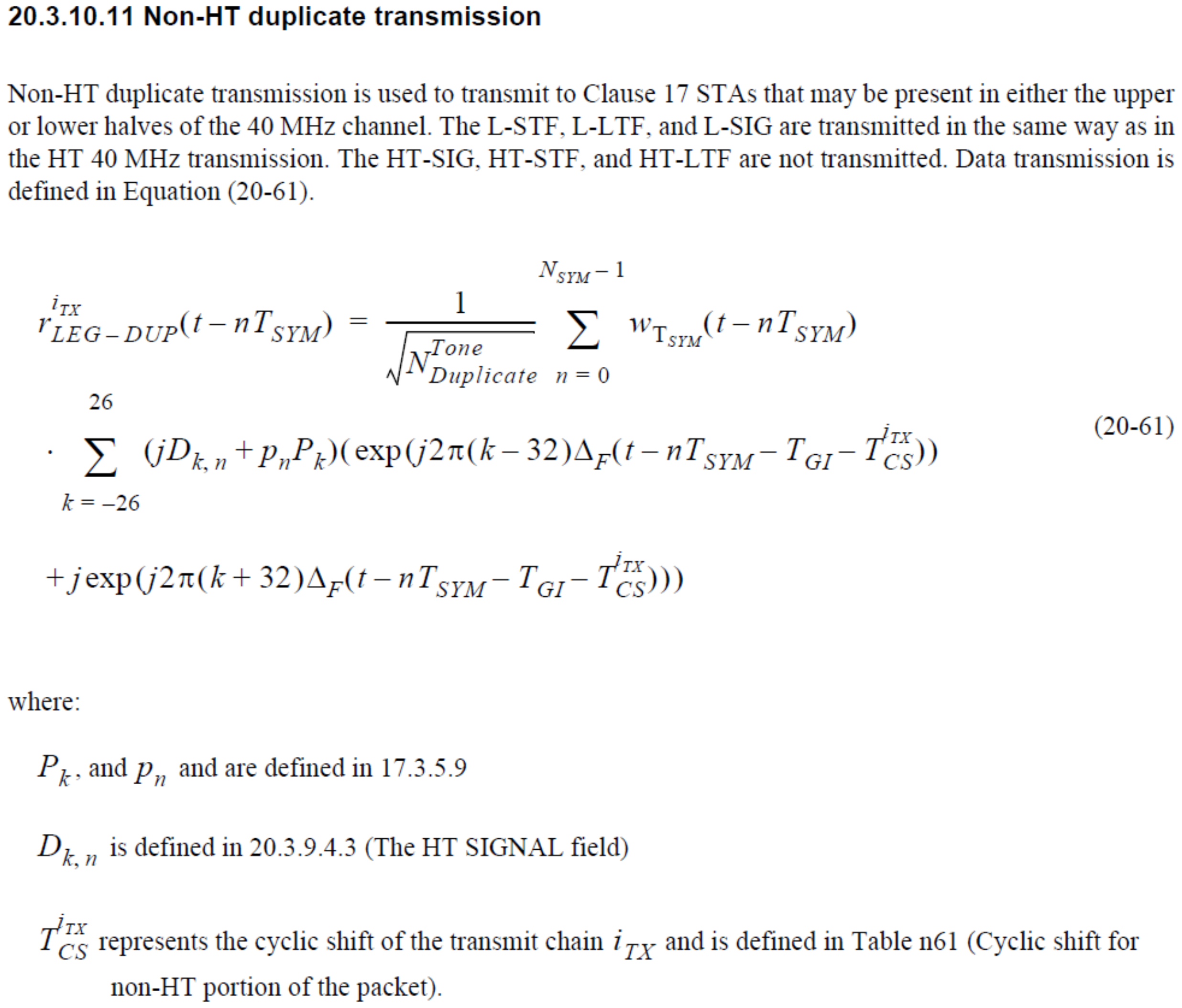
When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

Claim 13 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM})$ (20-58) $\cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P_{(i_{STS},n)}^{k}) \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

Claim 13 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS} \cdot N^{Tone}_{HT-DATA}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P^k_{(i_{STS}, n)}) \Upsilon_k \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T^{i_{STS}}_{CS}))$ (20-59) where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

Claim 13 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n}+p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1}\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI})) + j[Q_{k+32}]_{i_{TX},1}\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

<table>
<tr><th>Claim 13 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>



20.3.10.11 Non-HT duplicate transmission

Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61).

$$r^{i_{TX}}_{LEG-DUP}(t-nT_{SYM}) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}}\sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26}(jD_{k,n}+p_nP_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS}))) \qquad (20\text{-}61)$$

where:

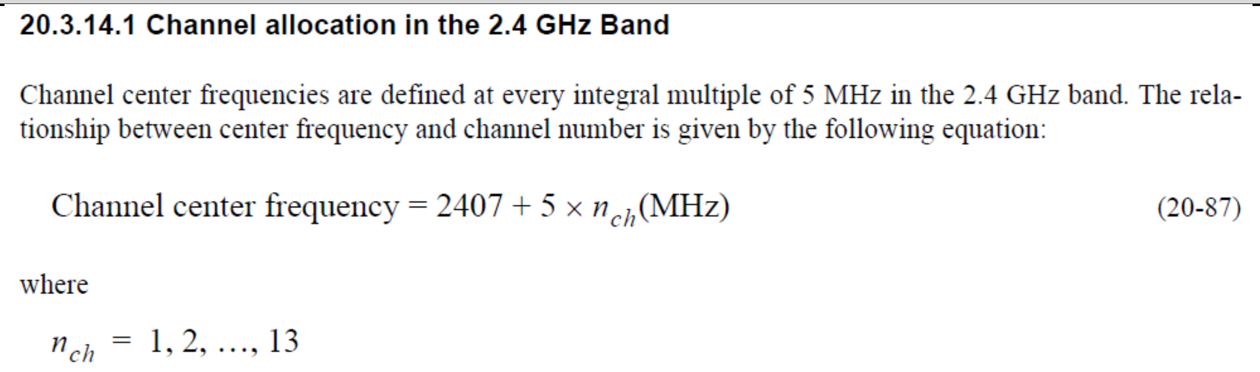
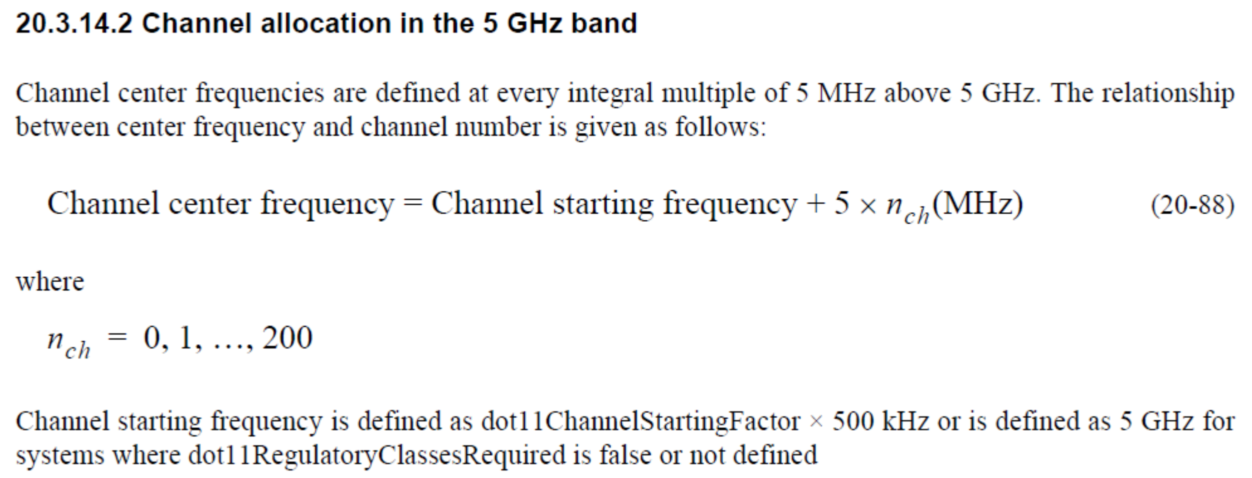
P_k, and p_n and are defined in 17.3.5.9

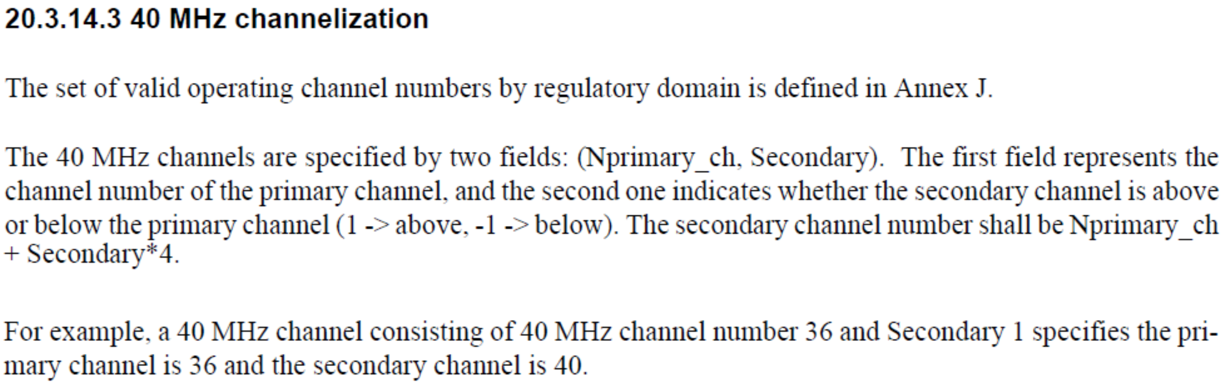
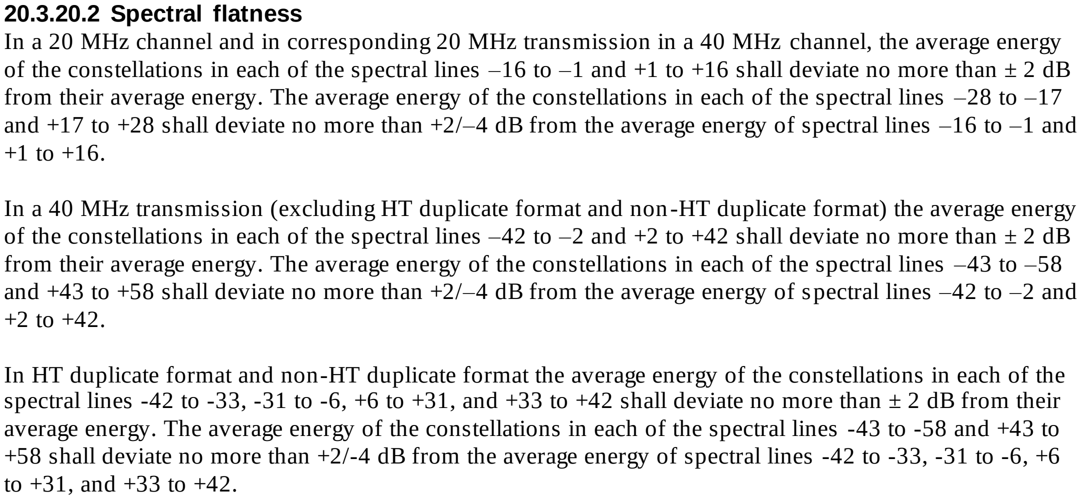
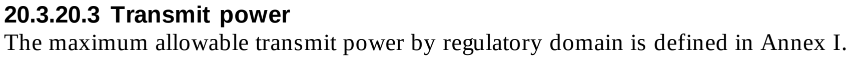
$D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field)

$T^{i_{TX}}_{CS}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet).

See, e.g., 802.11n D2.0 § 20.3.10.11

</td></tr>
</table>

Claim 13 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz}) \quad (20\text{-}87)$ where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz}) \quad (20\text{-}88)$ where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 13 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3  **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2  **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

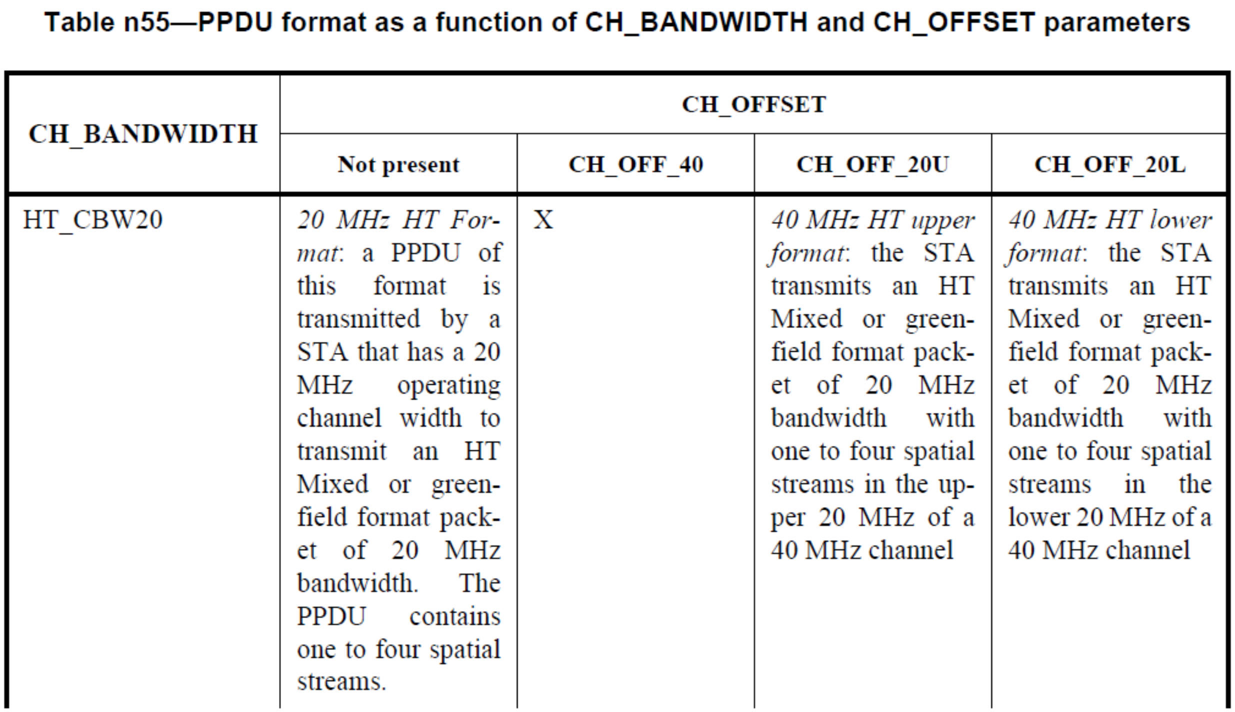
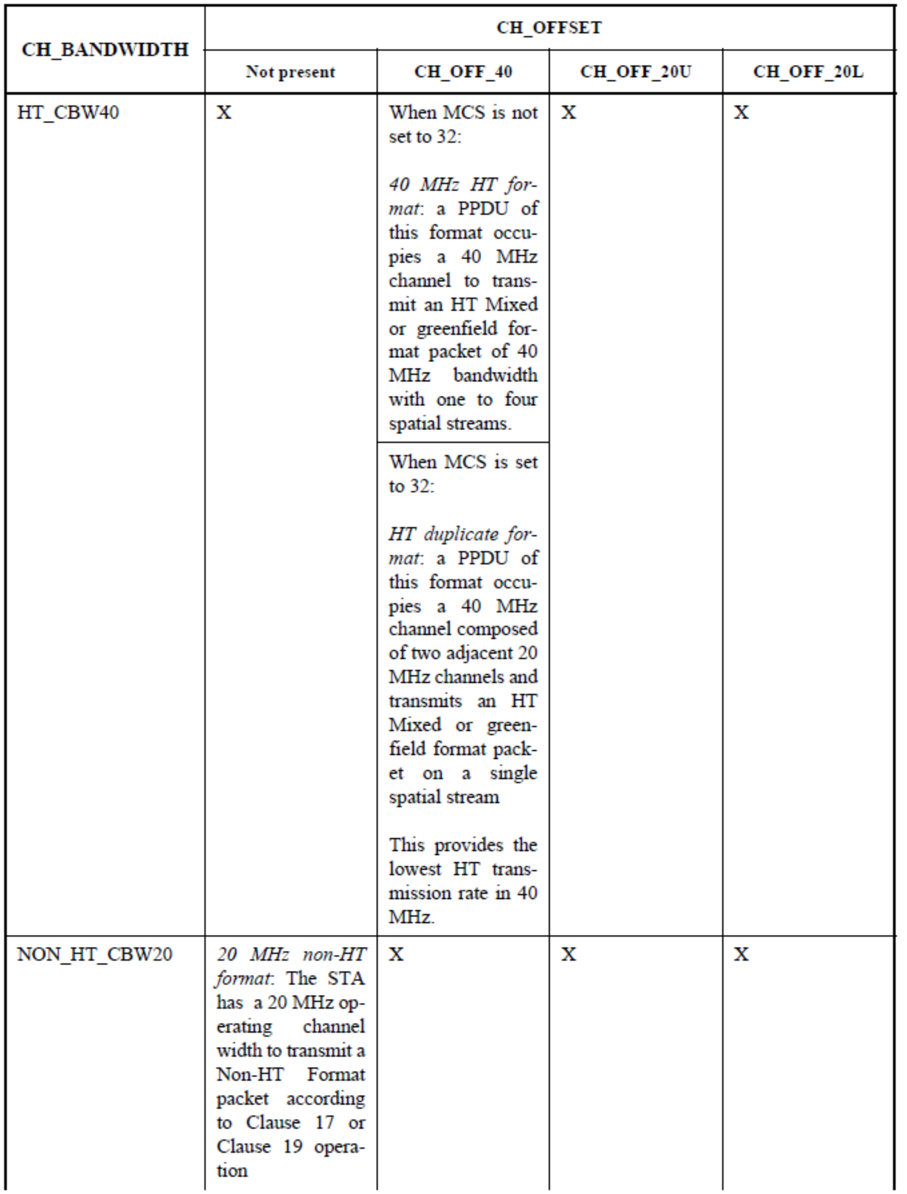
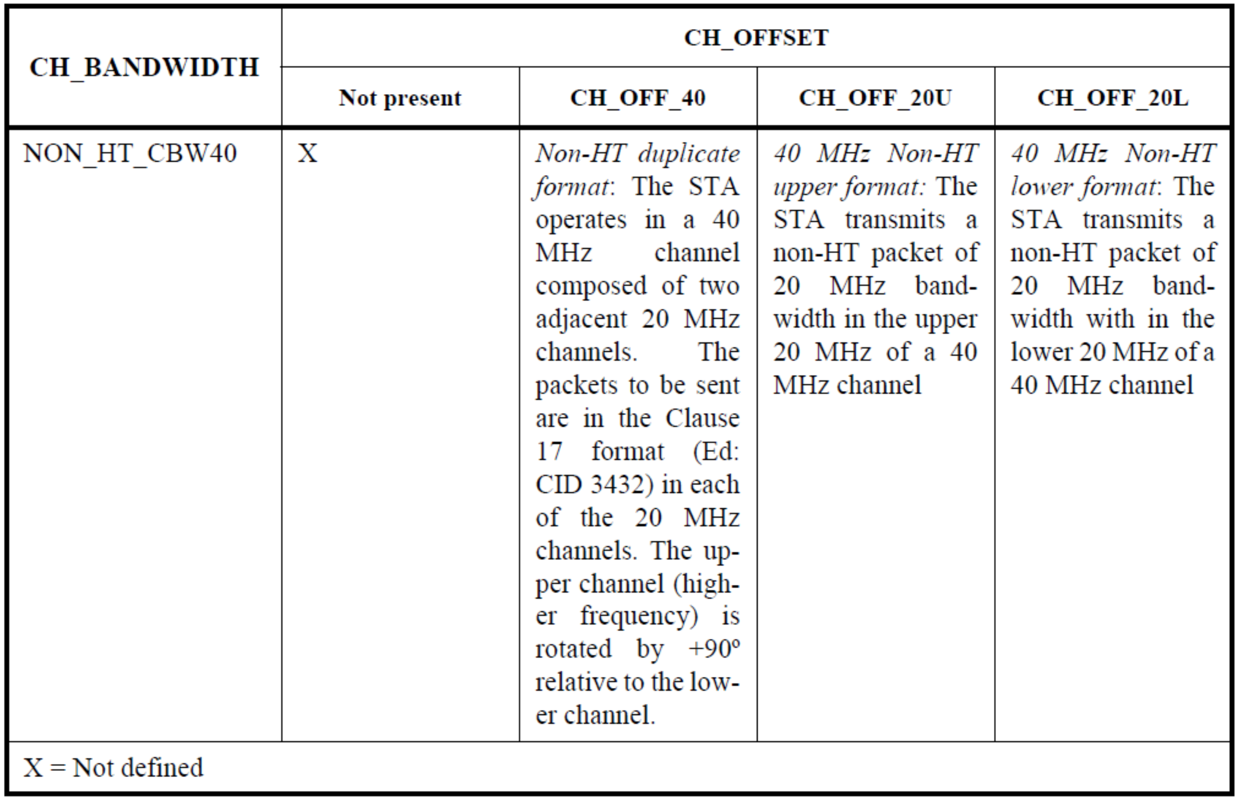
Claim 13 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.20.3 

Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

CH_BANDWIDTH	**CH_OFFSET**			
	Not present	**CH_OFF_40**	**CH_OFF_20U**	**CH_OFF_20L**
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel



CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

Claim 13 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 See, e.g., 802.11n D2.0 Table n55

CH_BANDWIDTH	**CH_OFFSET**			
	Not present	**CH_OFF_40**	**CH_OFF_20U**	**CH_OFF_20L**
NON_HT_CBW40	X	*Non-HT duplicate format*: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.	*40 MHz Non-HT upper format:* The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel	*40 MHz Non-HT lower format*: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel
X = Not defined				

Claim 13 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	Table n58—Timing related constants

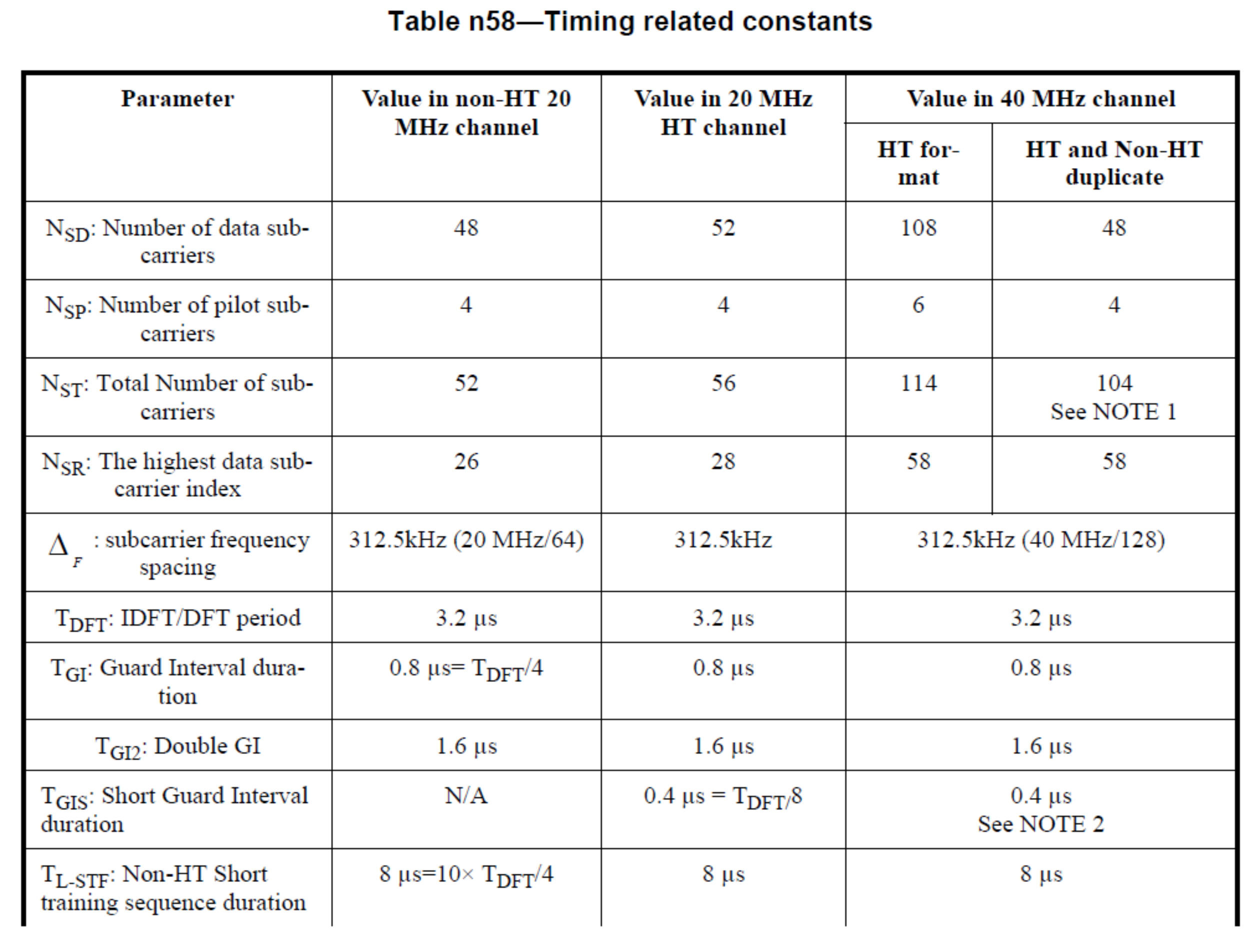
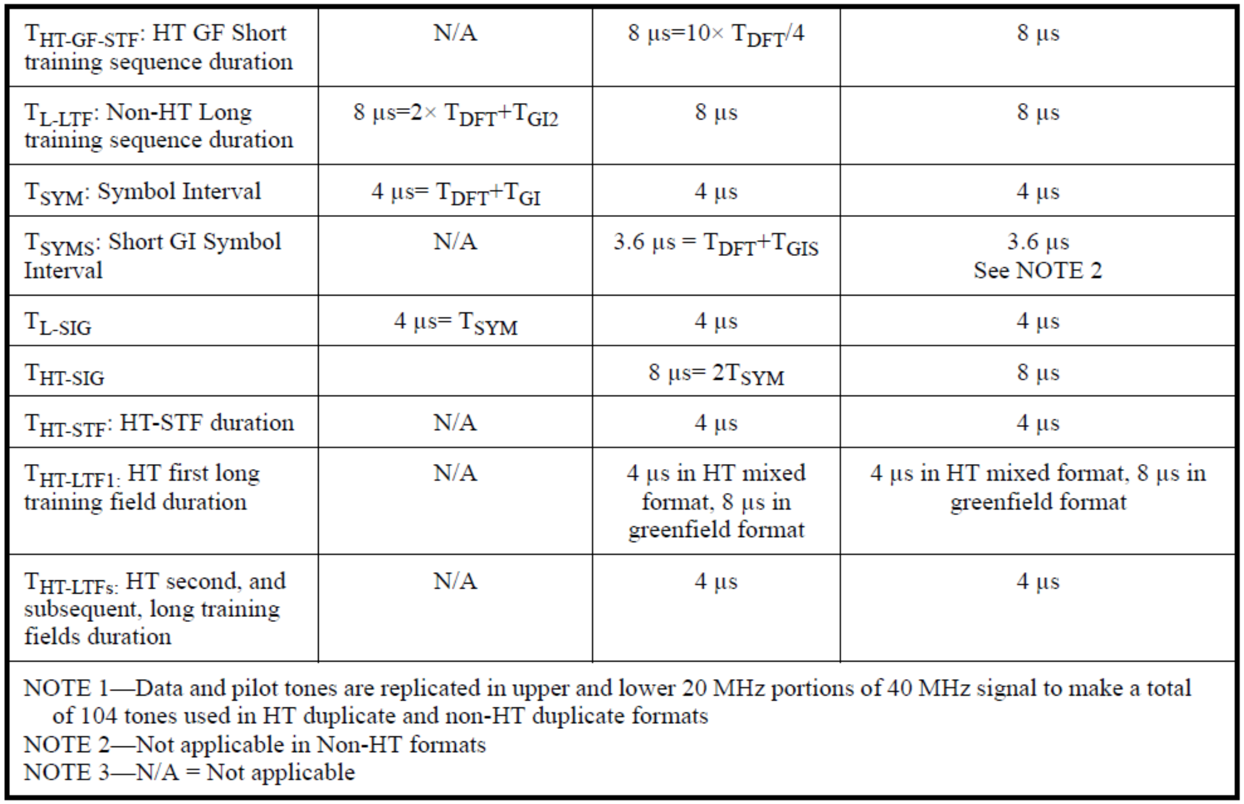


Table n58—Timing related constants

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

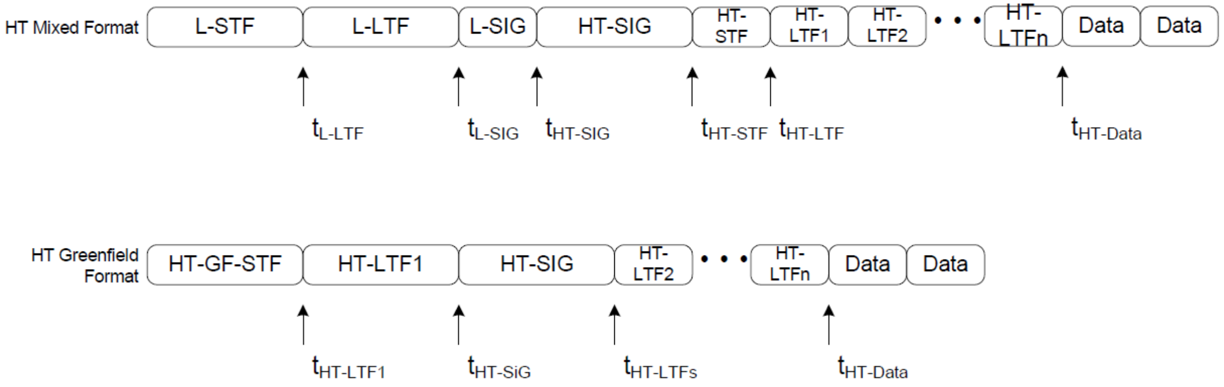
Claim 13 of the ’802 Patent	Prior Art Reference – 802.11n D2.0



$T_{HT\text{-}GF\text{-}STF}$: HT GF Short training sequence duration	N/A	8 µs=10× T_{DFT}/4	8 µs
$T_{L\text{-}LTF}$: Non-HT Long training sequence duration	8 µs=2× T_{DFT}+T_{GI2}	8 µs	8 µs
T_{SYM}: Symbol Interval	4 µs= T_{DFT}+T_{GI}	4 µs	4 µs
T_{SYMS}: Short GI Symbol Interval	N/A	3.6 µs = T_{DFT}+T_{GIS}	3.6 µs See NOTE 2
$T_{L\text{-}SIG}$	4 µs= T_{SYM}	4 µs	4 µs
$T_{HT\text{-}SIG}$		8 µs= 2T_{SYM}	8 µs
$T_{HT\text{-}STF}$: HT-STF duration	N/A	4 µs	4 µs
$T_{HT\text{-}LTF1:}$ HT first long training field duration	N/A	4 µs in HT mixed format, 8 µs in greenfield format	4 µs in HT mixed format, 8 µs in greenfield format
$T_{HT\text{-}LTFs:}$ HT second, and subsequent, long training fields duration	N/A	4 µs	4 µs

NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable

See, e.g., 802.11n D2.0 Table n58

Claim 13 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
[14.1] The method of claim 10	802.11n D2.0 discloses all the elements of claim 10 for all the reasons provided above.
[14.2] wherein the second data is the same as the first	802.11n D2.0 discloses “wherein the second data is the same as the first data, the method further comprising.” See, e.g.:

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
data, the method further comprising:	**high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19 **non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0

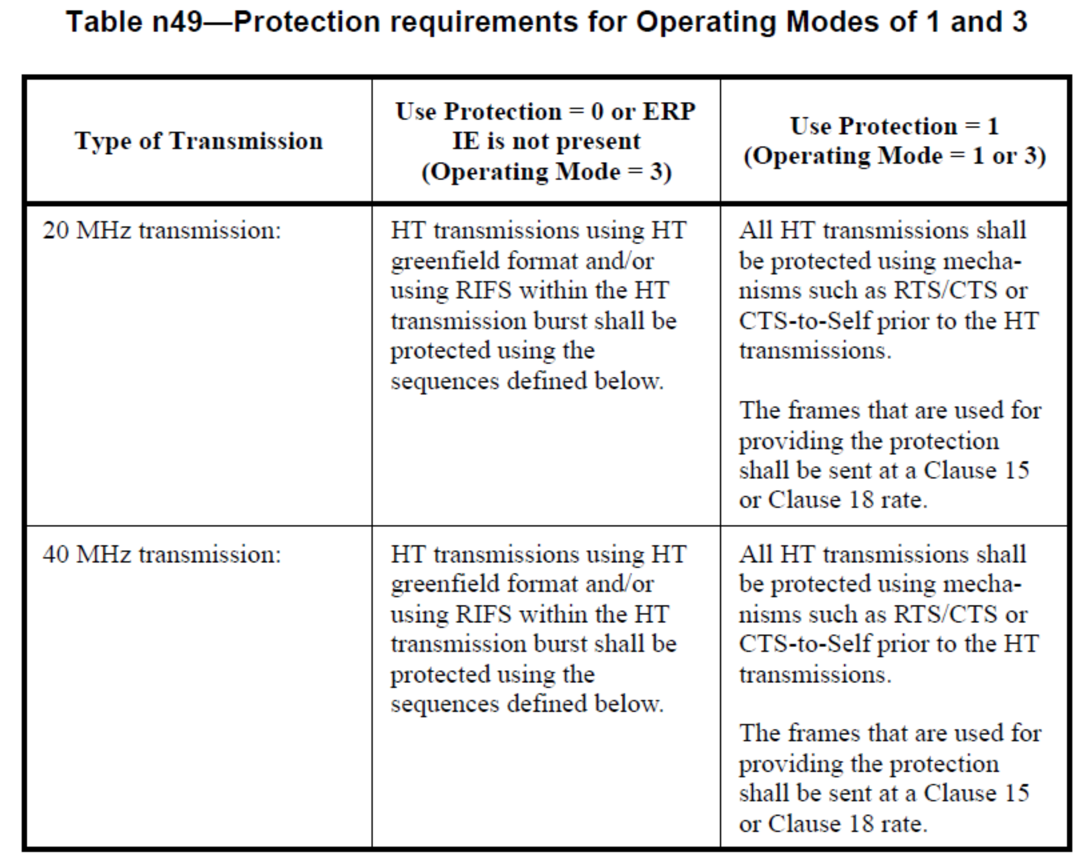


Table n49—Protection requirements for Operating Modes of 1 and 3

Type of Transmission	Use Protection = 0 or ERP IE is not present (Operating Mode = 3)	Use Protection = 1 (Operating Mode = 1 or 3)
20 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.
40 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:

a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:

1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19

2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.

NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).

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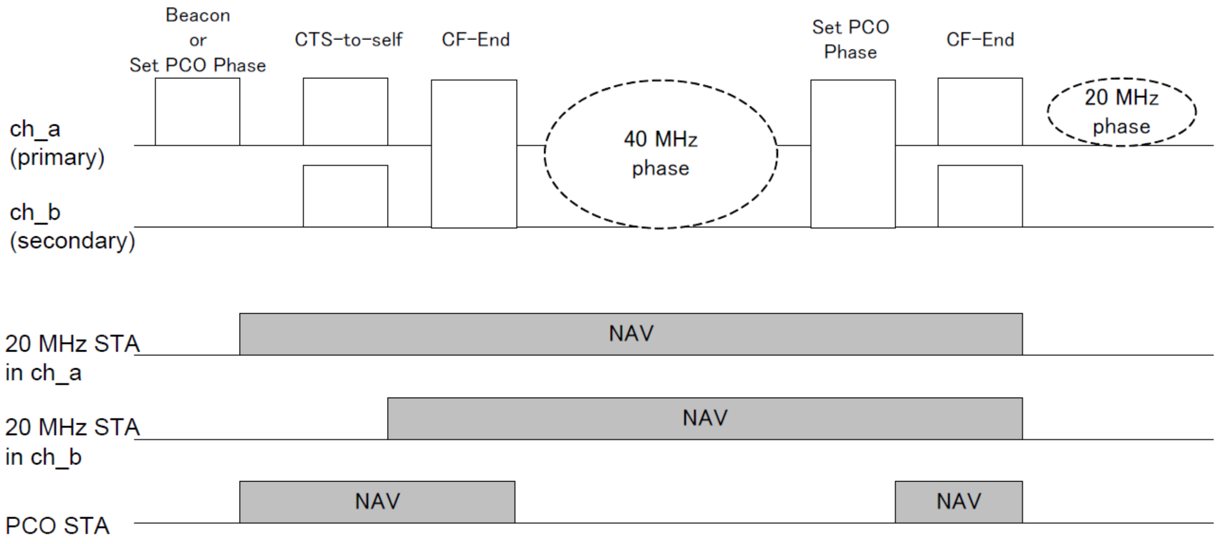
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

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	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

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	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

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	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

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	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

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	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $$r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t \right) \right\} \quad (20\text{-}1)$$ where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

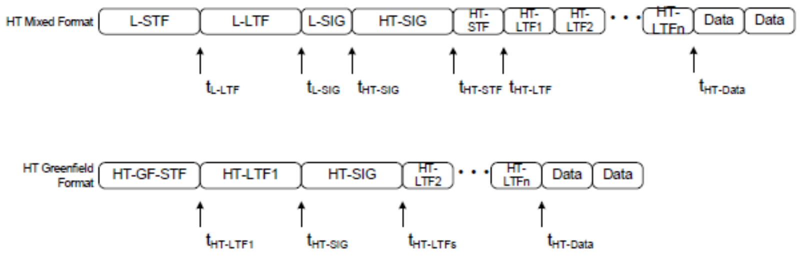

Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field}, determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned}
r_{PPDU}^{(i_{TX})}(t) = {} & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\
& + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\
& + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\
& + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\
& + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right)T_{HT-LTFs}\right) \\
& + r_{HT-DATA}^{(i_{TX})}\left(t - t_{HT-DATA}\right)
\end{aligned} \tag{20-2}$$

where

$$t_{L-LTF} = T_{L-STF}$$

$$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$$

$$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$$

$$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$r_{PPDU}^{(i_{TX})}(t) = r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1})$$

$$+ r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG})$$

$$+ \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2)T_{HT-LTFs})$$

$$+ r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \qquad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\text{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\text{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j2\pi k \Delta_F t) \qquad (20\text{-}4)$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \qquad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \qquad (20\text{-}6)$$

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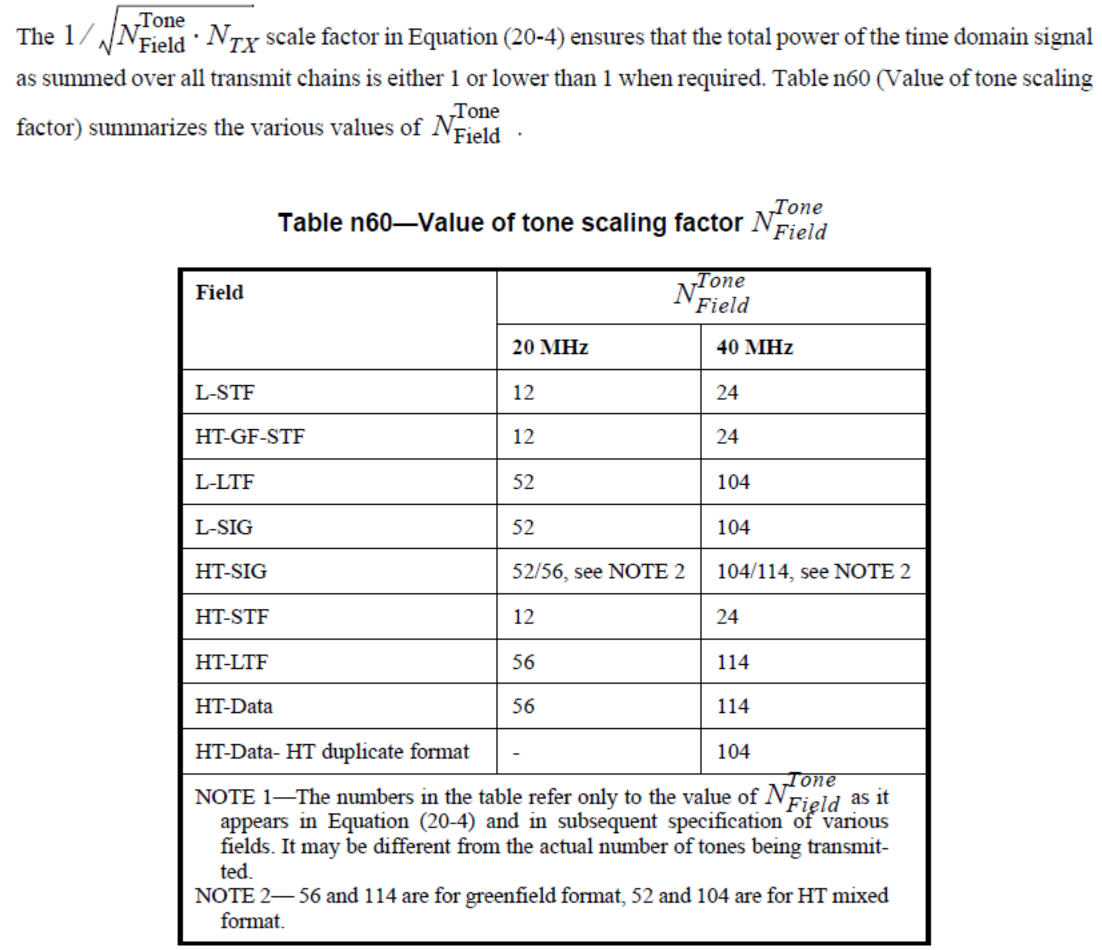

The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	**40 MHz**
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

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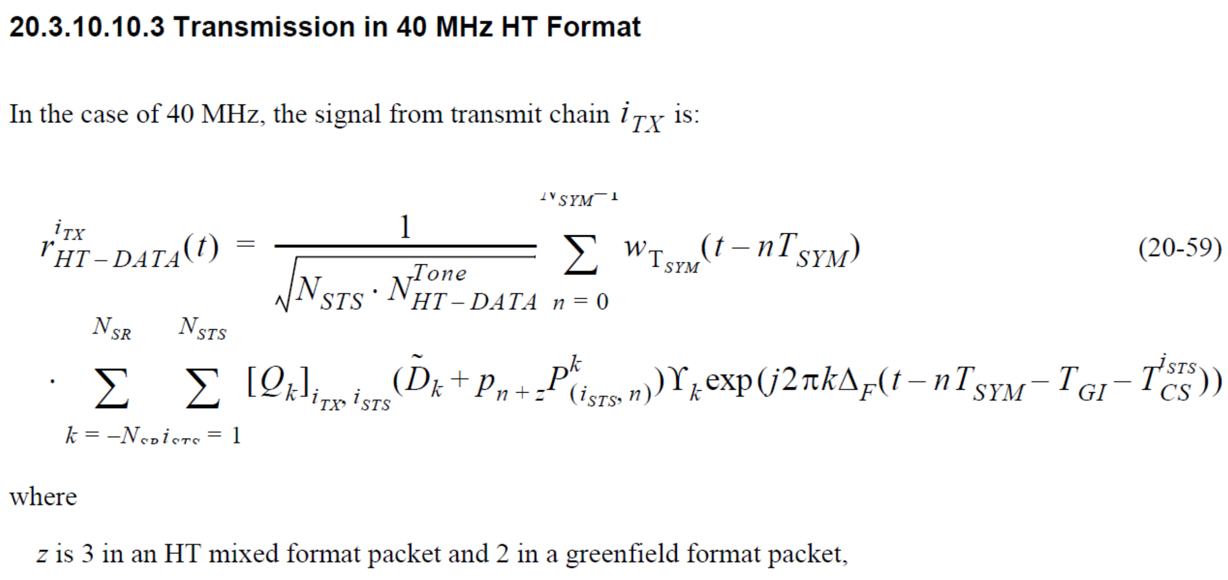
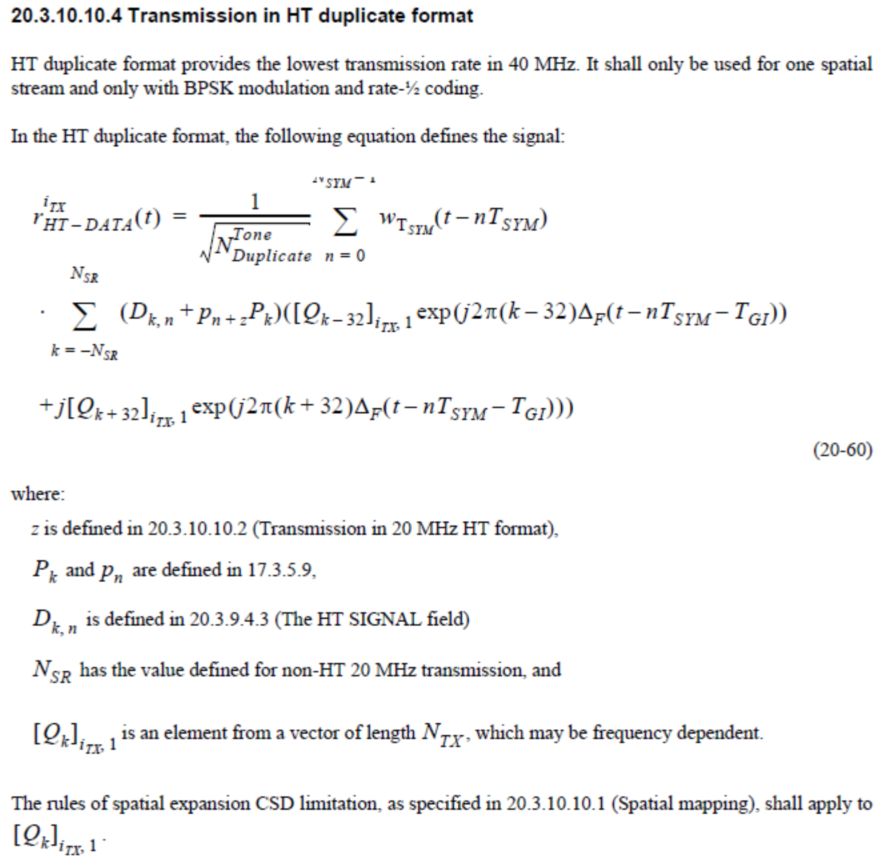
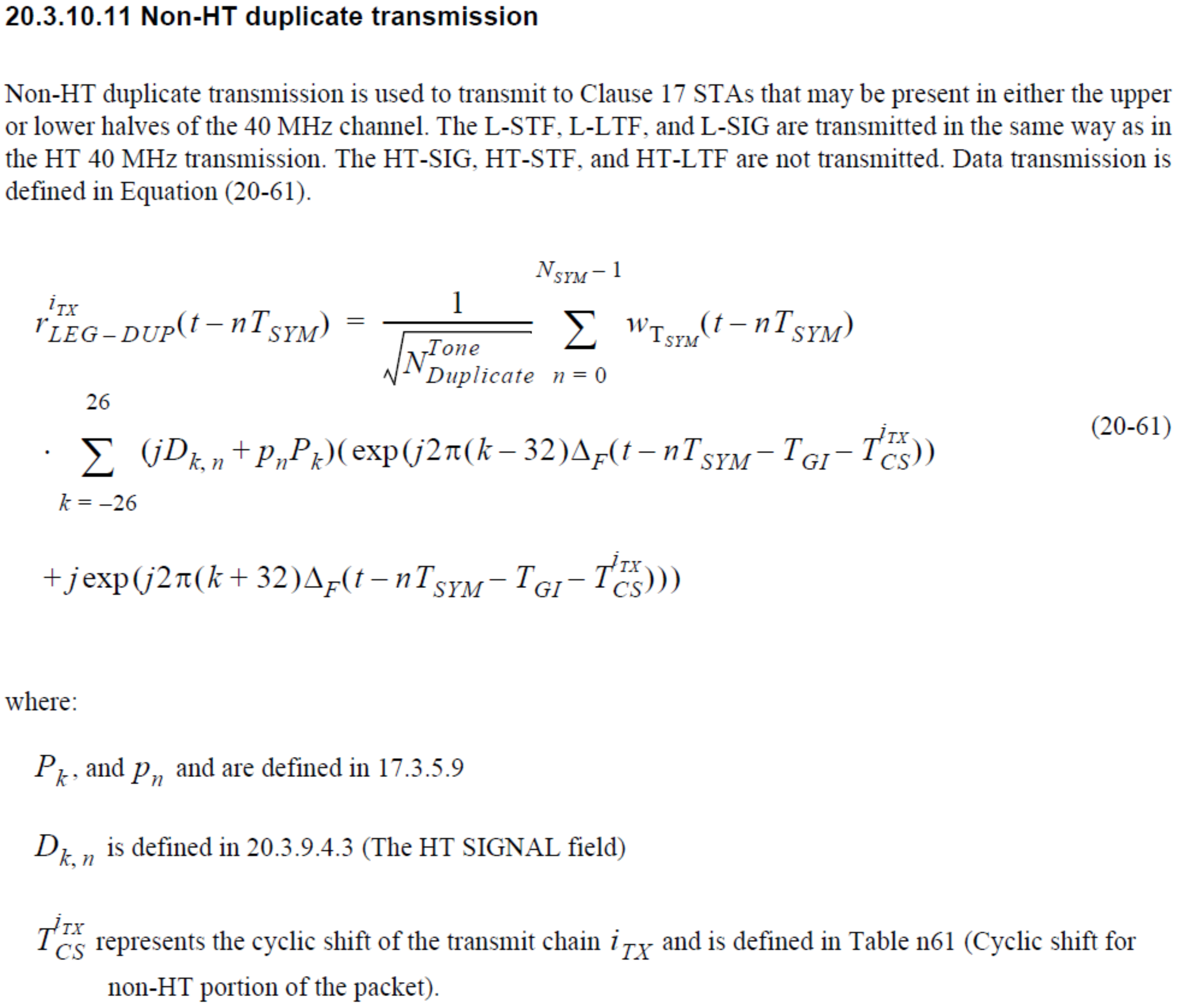
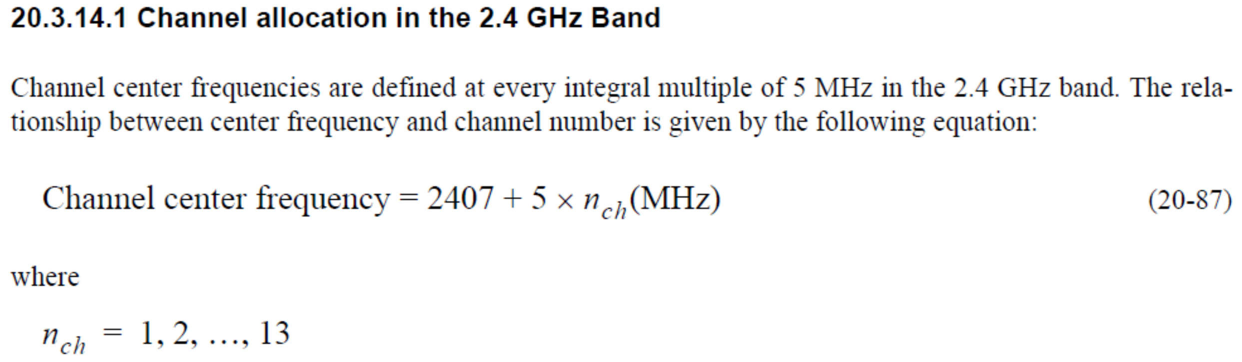
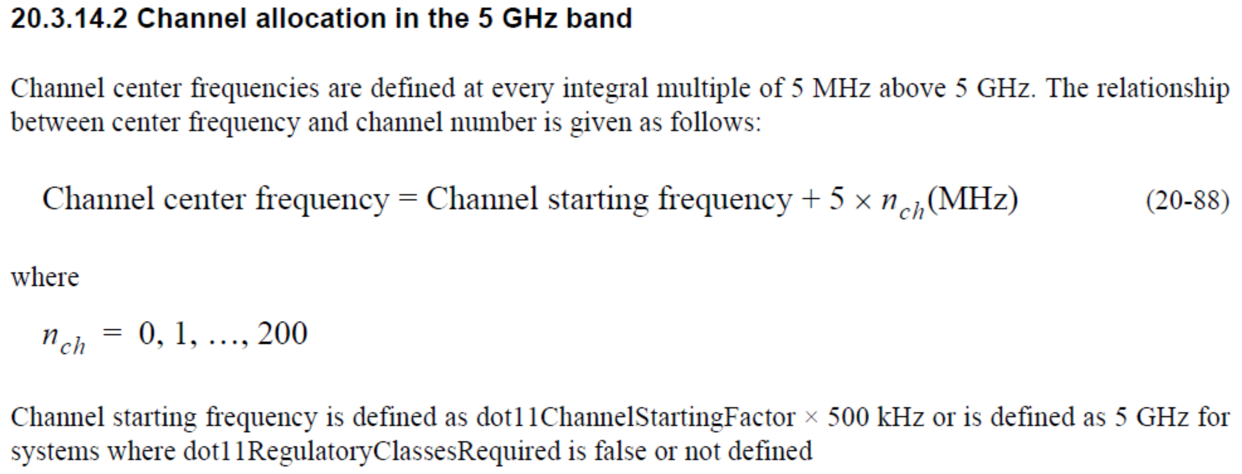
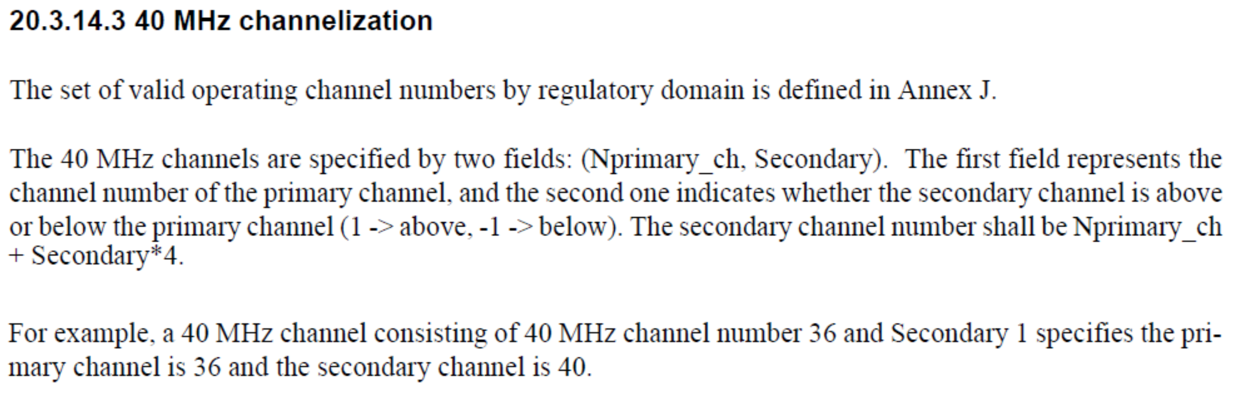
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P_{(i_{STS},n)}^{k}) \exp(j 2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (20-58) where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

Claim 14 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P^k_{(i_{STS}, n)}) \Upsilon_k \exp(j2\pi k\Delta_F(t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (20-59) where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n}+p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI})) + j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $$r^{i_{TX}}_{LEG-DUP}(t-nT_{SYM}) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}}\sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26}(jD_{k,n}+p_nP_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})))$$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T^{i_{TX}}_{CS}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz}) \quad (20\text{-}87)$ where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz}) \quad (20\text{-}88)$ where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

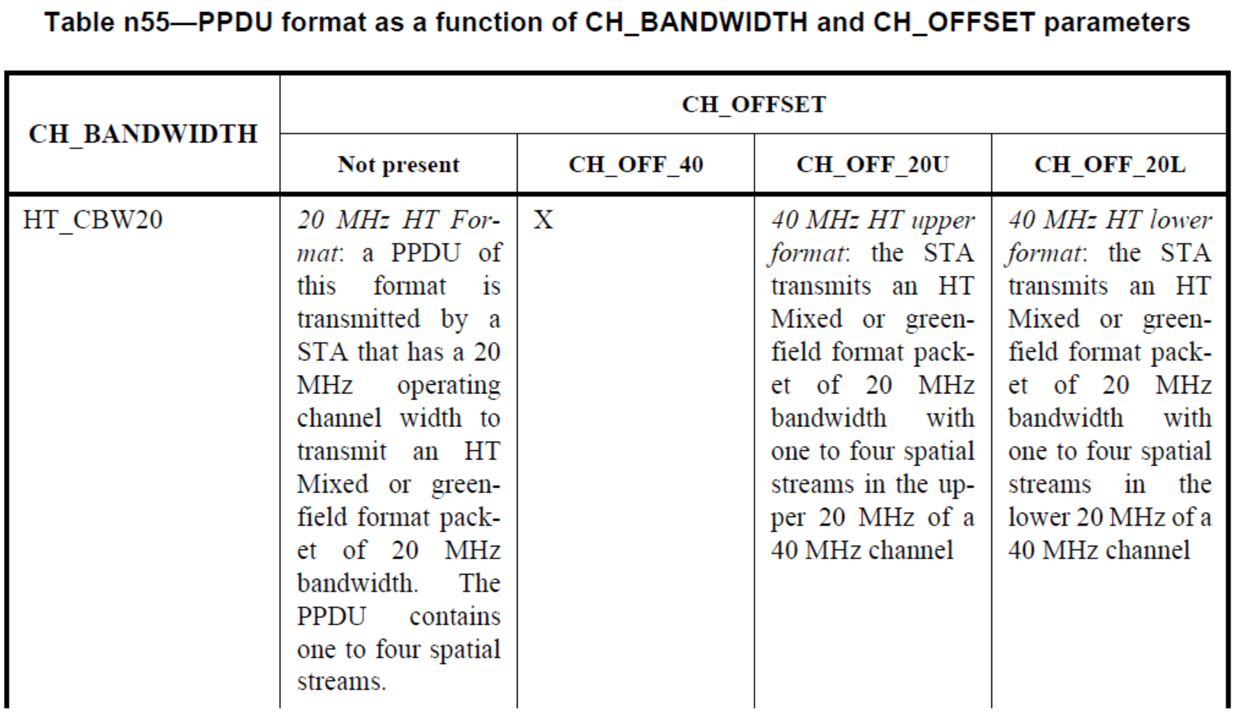
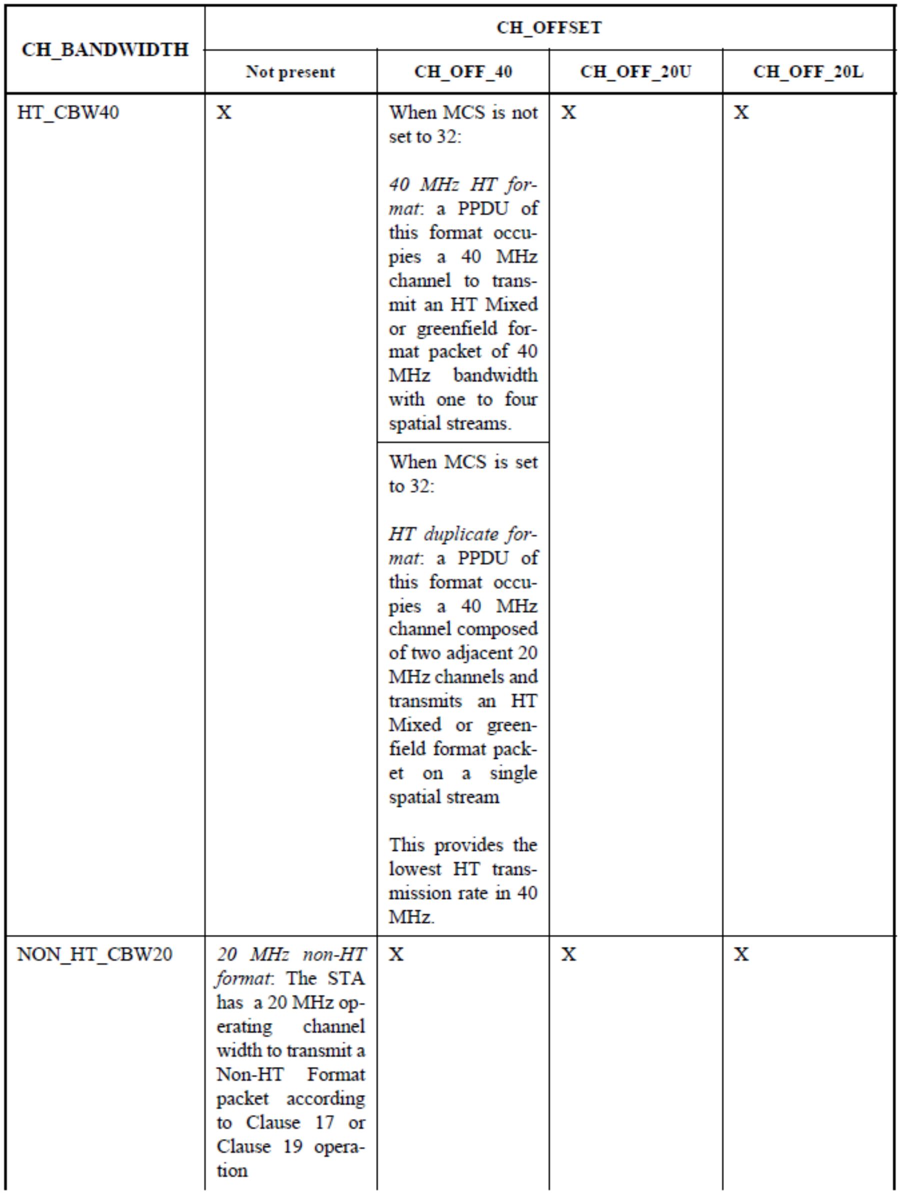
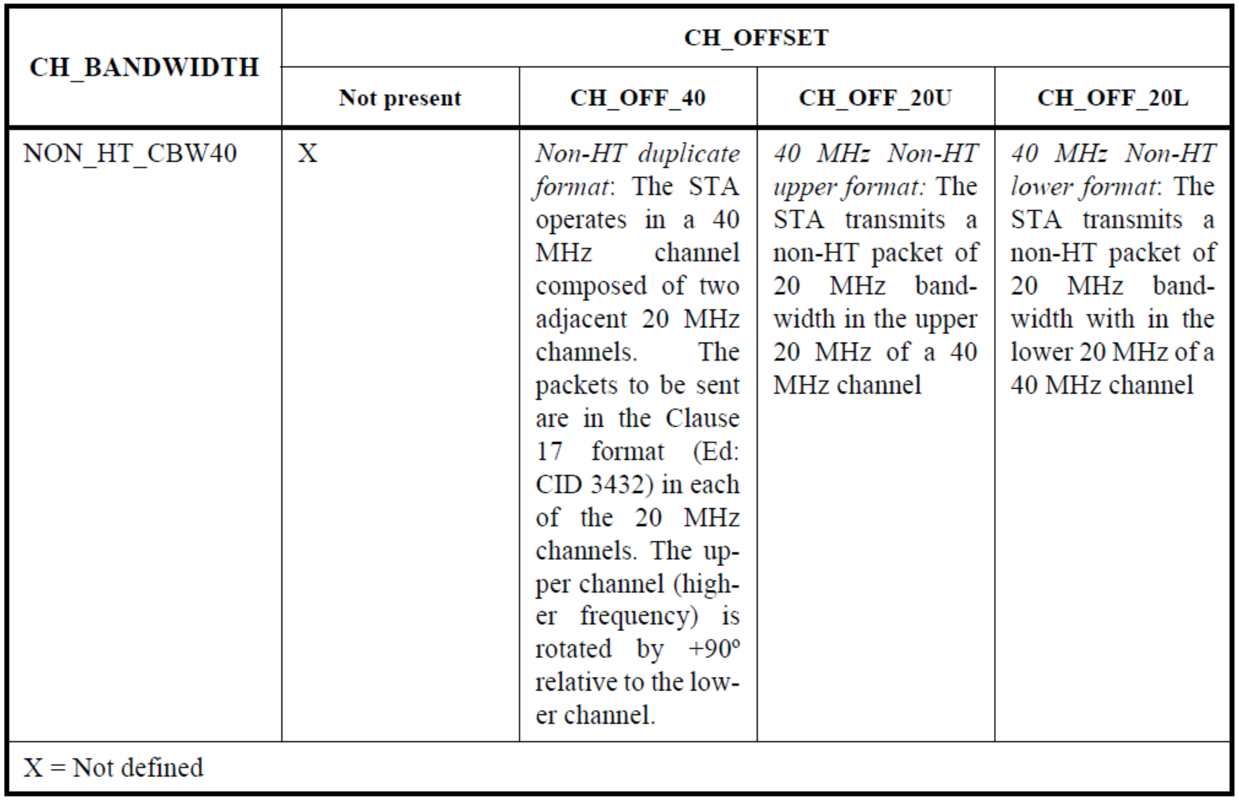
Claim 14 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.20.3 

Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

CH_BANDWIDTH	**CH_OFFSET**			
	Not present	**CH_OFF_40**	**CH_OFF_20U**	**CH_OFF_20L**
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel



CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	

CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
NON_HT_CBW40	X	*Non-HT duplicate format*: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.	*40 MHz Non-HT upper format:* The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel	*40 MHz Non-HT lower format*: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel
X = Not defined				

See, e.g., 802.11n D2.0 Table n55

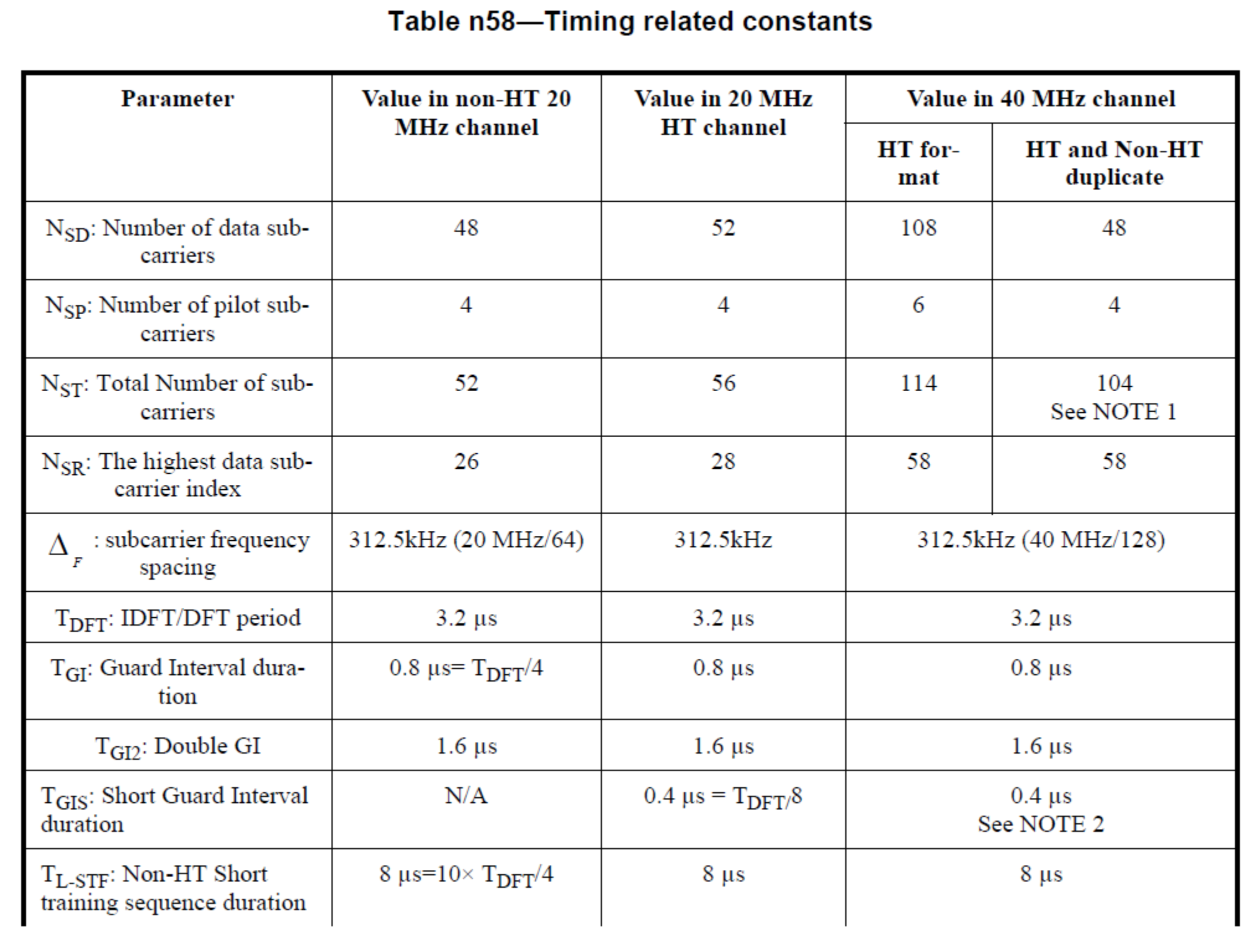
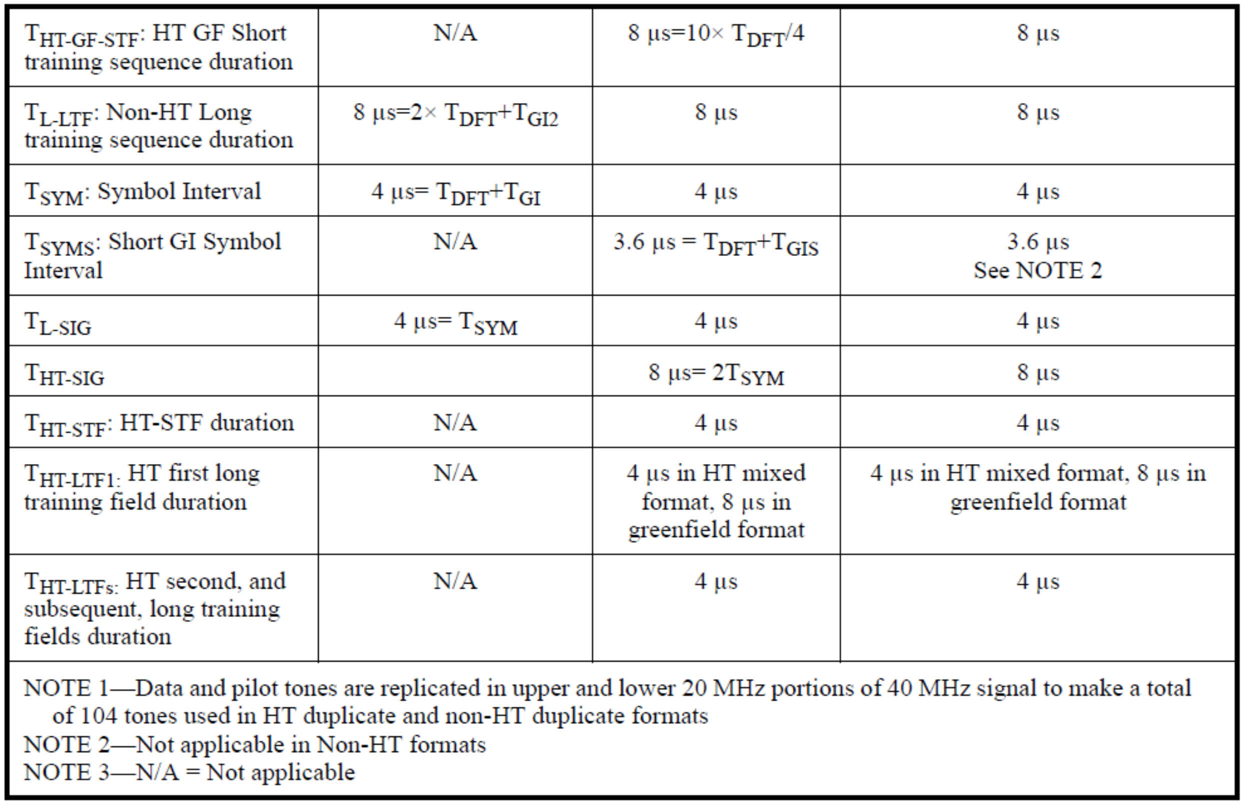
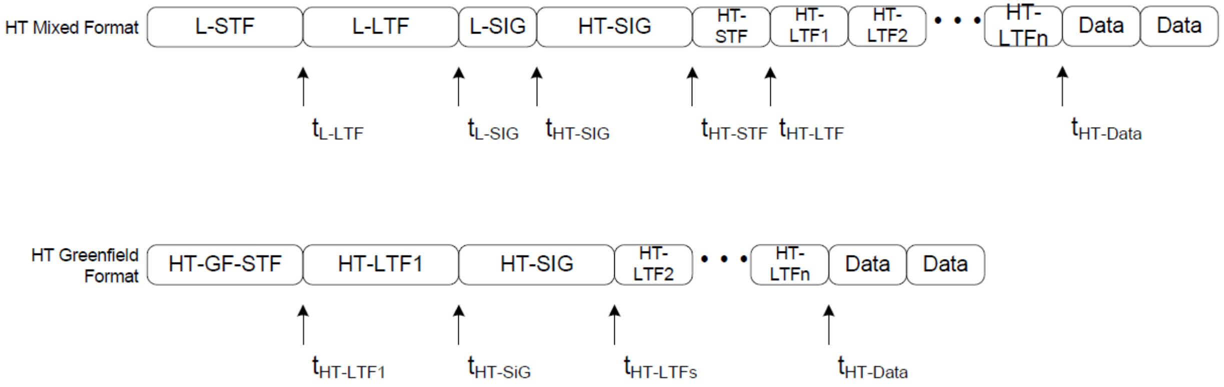
Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	

Table n58—Timing related constants

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

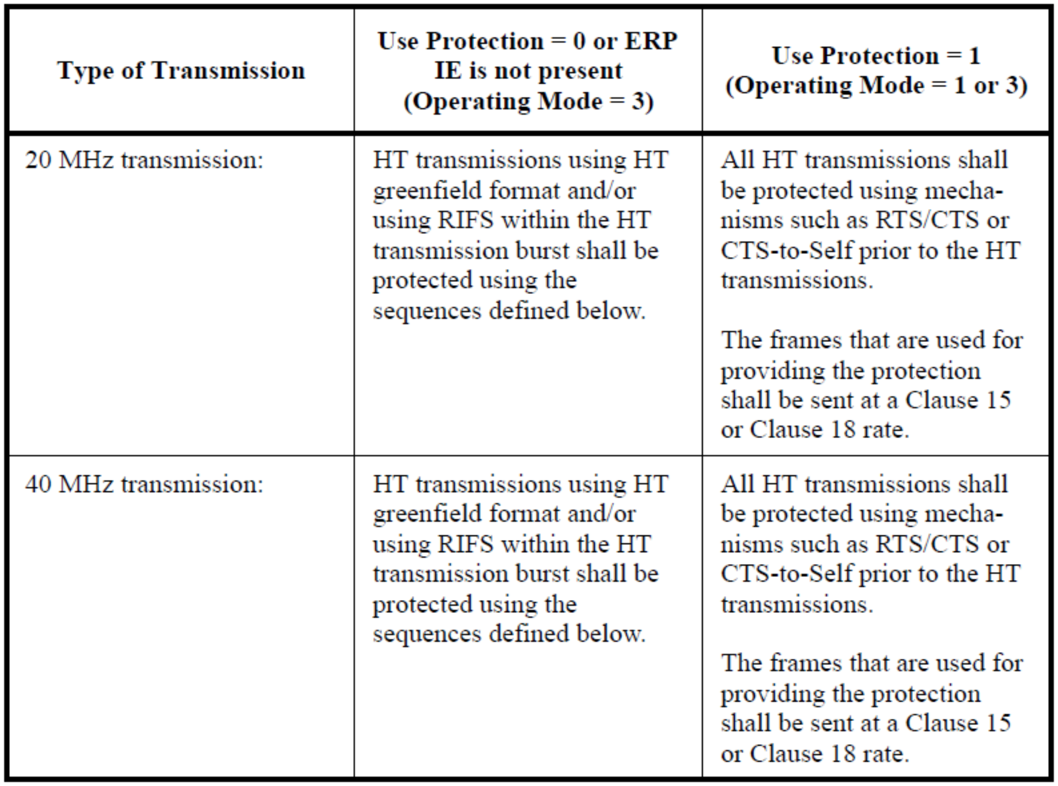
<table>
<tr><th>Claim 14 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><td>$T_{HT-GF-STF}$: HT GF Short training sequence duration</td><td>N/A</td><td>8 μs=10× T_{DFT}/4</td><td>8 μs</td></tr>
<tr><td>T_{L-LTF}: Non-HT Long training sequence duration</td><td>8 μs=2× T_{DFT}+T_{GI2}</td><td>8 μs</td><td>8 μs</td></tr>
<tr><td>T_{SYM}: Symbol Interval</td><td>4 μs= T_{DFT}+T_{GI}</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td>T_{SYMS}: Short GI Symbol Interval</td><td>N/A</td><td>3.6 μs = T_{DFT}+T_{GIS}</td><td>3.6 μs
See NOTE 2</td></tr>
<tr><td>T_{L-SIG}</td><td>4 μs= T_{SYM}</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td>T_{HT-SIG}</td><td></td><td>8 μs= 2T_{SYM}</td><td>8 μs</td></tr>
<tr><td>T_{HT-STF}: HT-STF duration</td><td>N/A</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td>$T_{HT-LTF1:}$ HT first long training field duration</td><td>N/A</td><td>4 μs in HT mixed format, 8 μs in greenfield format</td><td>4 μs in HT mixed format, 8 μs in greenfield format</td></tr>
<tr><td>$T_{HT-LTFs:}$ HT second, and subsequent, long training fields duration</td><td>N/A</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td colspan="4">NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n58
</td></tr>
</table>

Claim 14 of the '802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.
[14.3] receiving the transmitted signal on a second antenna;	802.11n D2.0 discloses "receiving the transmitted signal on a second antenna." See, e.g.: **high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19 **non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission.

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

Claim 14 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**

Table n49—Protection requirements for Operating Modes of 1 and 3



Type of Transmission	Use Protection = 0 or ERP IE is not present (Operating Mode = 3)	Use Protection = 1 (Operating Mode = 1 or 3)
20 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.
40 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:

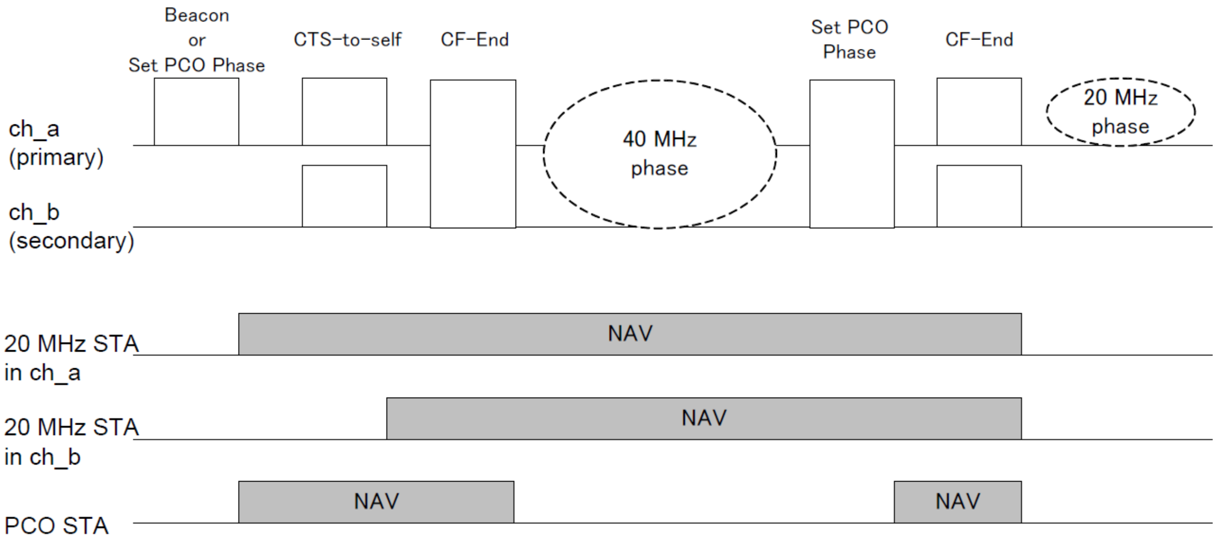
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:

1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19

2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.

NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

Claim 14 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format*: packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format*: packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format*: HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

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	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

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	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

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	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

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	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t\right)\right\}$ (20-1) where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

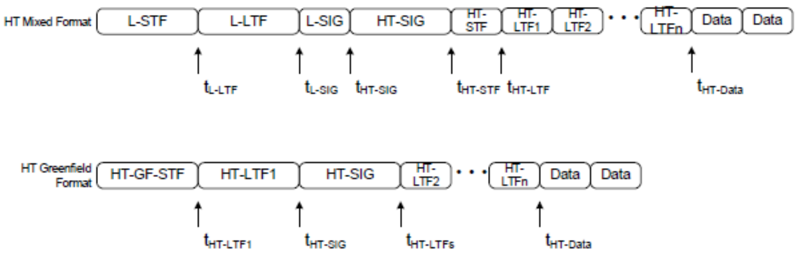

Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) &= r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t-t_{L-LTF}\right) \\ &\quad + r_{L-SIG}^{(i_{TX})}\left(t-t_{L-SIG}\right) \\ &\quad + r_{HT-SIG}^{(i_{TX})}\left(t-t_{HT-SIG}\right) \\ &\quad + r_{HT-STF}^{(i_{TX})}\left(t-t_{HT-STF}\right) \\ &\quad + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t-t_{HT-LTF}-\left(i_{LTF}-1\right)T_{HT-LTFs}\right) \\ &\quad + r_{HT-DATA}^{(i_{TX})}(t-t_{HT-DATA}) \end{aligned} \qquad (20\text{-}2)$$

where

$$t_{L-LTF} = T_{L-STF}$$

$$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$$

$$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$$

$$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r^{(i_{TX})}_{PPDU}(t) = {} & r^{(i_{TX})}_{HT-GF-STF}(t) + r^{(i_{TX})}_{HT-LTF1}(t - t_{HT-LTF1}) \\ & + r^{(i_{TX})}_{HT-SIG}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r^{(i_{TX}, i_{LTF})}_{HT-LTF}(t - t_{HT-LTFs} - (i_{LTF} - 2)T_{HT-LTFs}) \\ & + r^{(i_{TX})}_{HT-DATA}(t - t_{HT-DATA}) \end{aligned} \quad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r^{(i_{TX})}_{\text{Field}}(t)$, is defined via the discrete Fourier transform as

$$r^{(i_{TX})}_{\text{Field}}(t) = \frac{1}{\sqrt{N^{\text{Tone}}_{\text{Field}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X^{(i_{TX})}_k \exp(j2\pi k \Delta_F t) \quad (20\text{-}4)$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X^{(i_{TX})}_k$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \quad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \quad (20\text{-}6)$$

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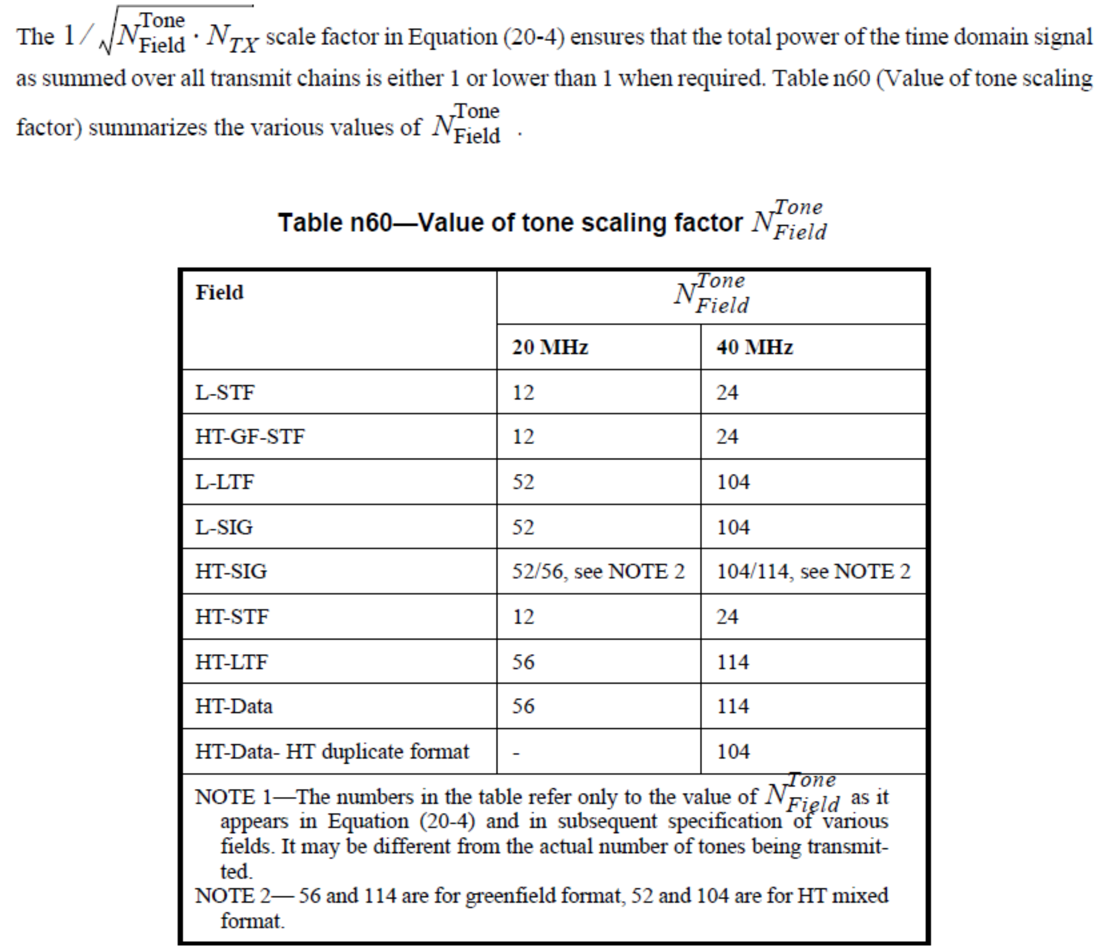

The $1 / \sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	40 MHz
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

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	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM})$ (20-58) $\cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P^k_{(i_{STS}, n)}) \exp(j 2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

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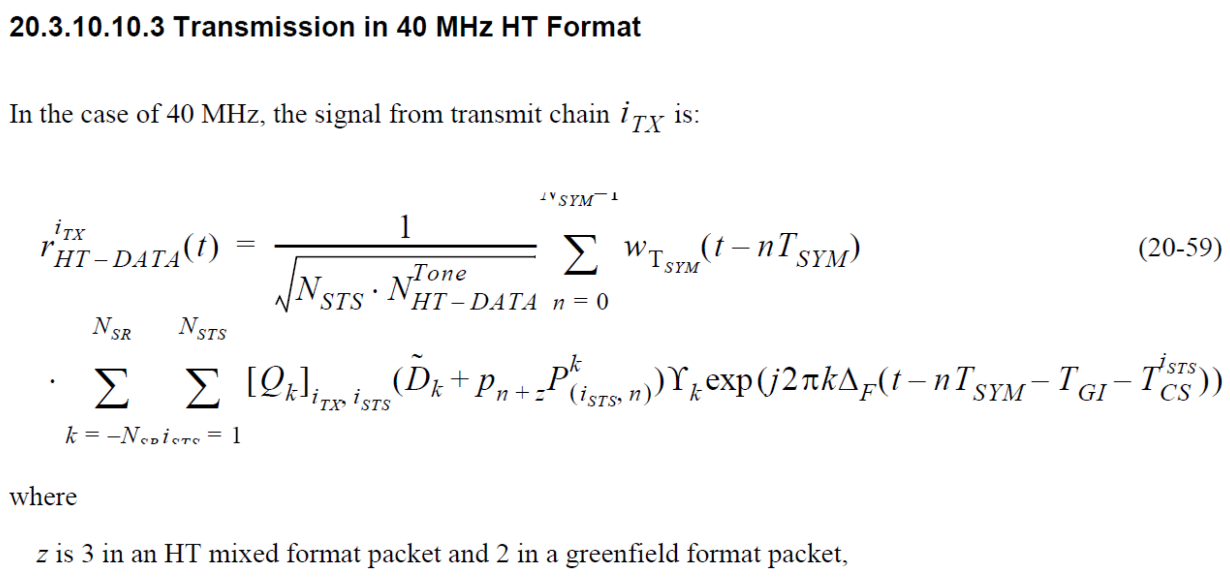
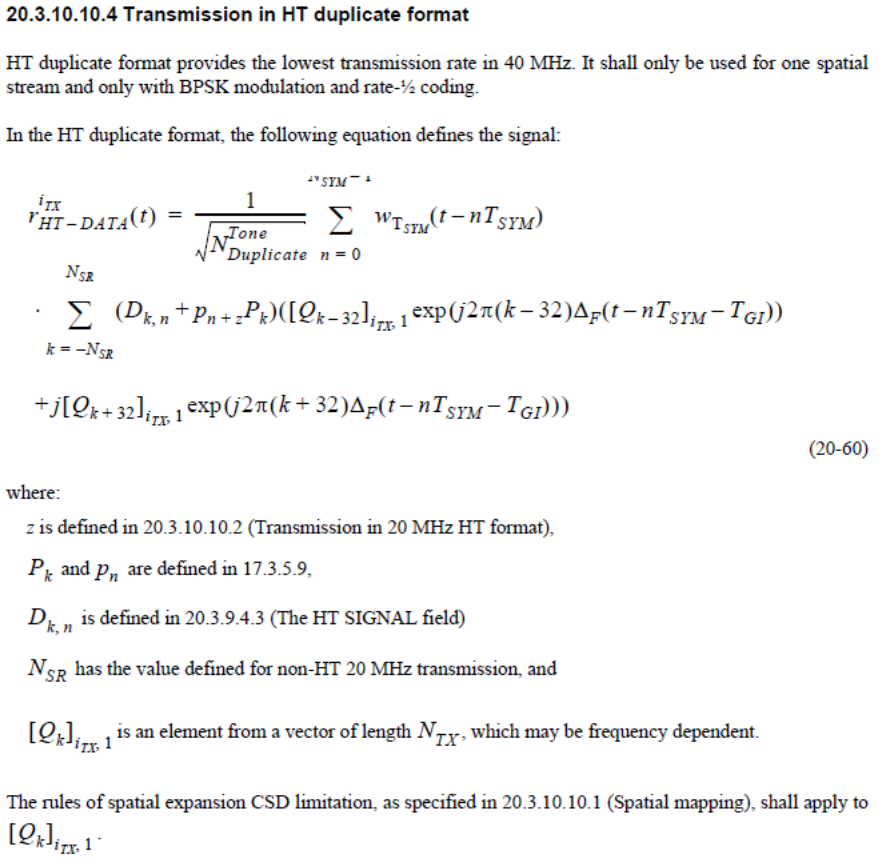
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $$r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS}\cdot N^{Tone}_{HT-DATA}}}\sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}}\sum_{i_{STS}=1}^{N_{STS}}[Q_k]_{i_{TX},i_{STS}}(\tilde{D}_k + p_{n+z}P^k_{(i_{STS},n)})\Upsilon_k \exp(j2\pi k\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{STS}}_{CS})) \qquad (20\text{-}59)$$ where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

Claim 14 of the '802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM})$ $\cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n} + p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t - nT_{SYM} - T_{GI}))$ $+ j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t - nT_{SYM} - T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

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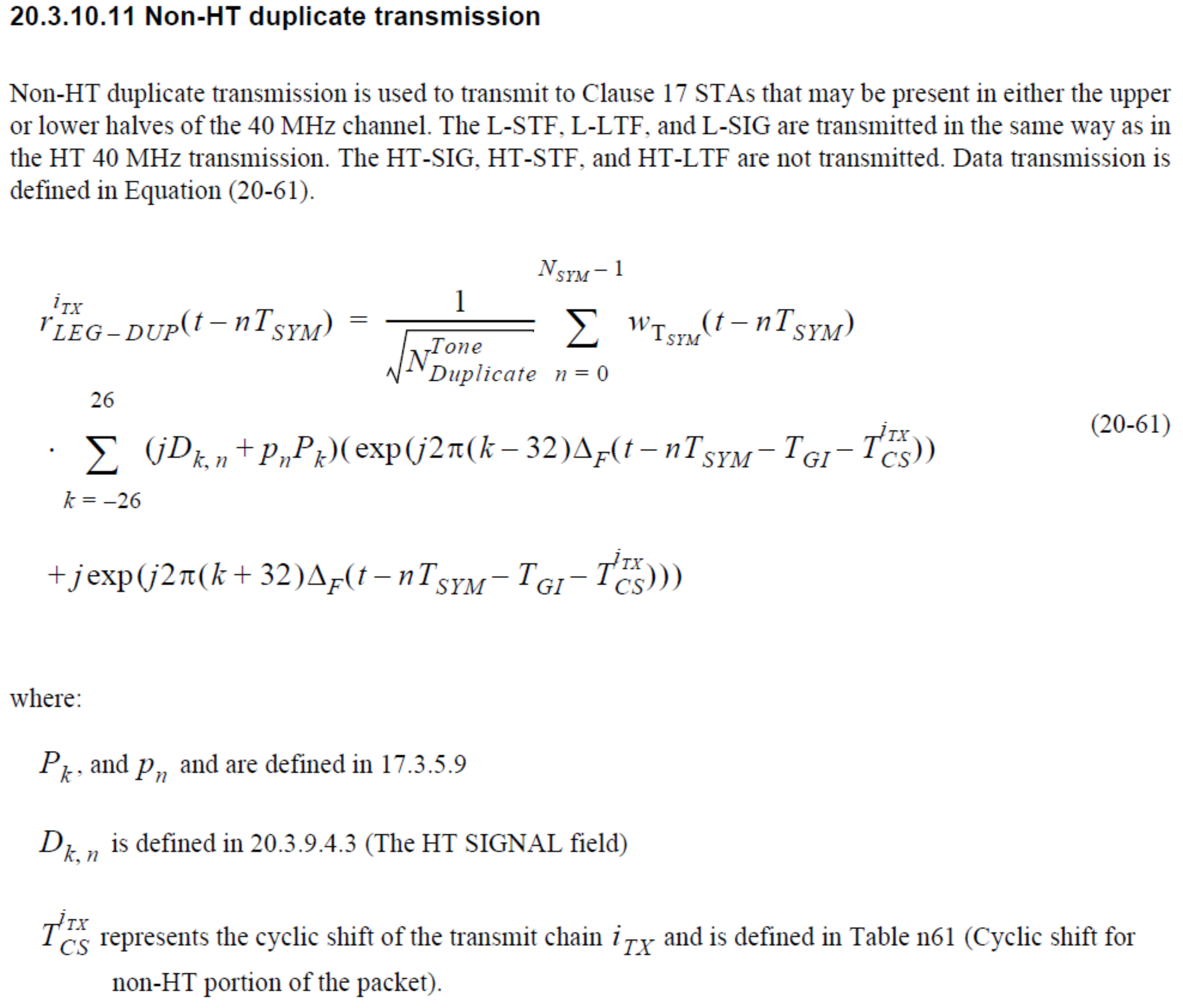
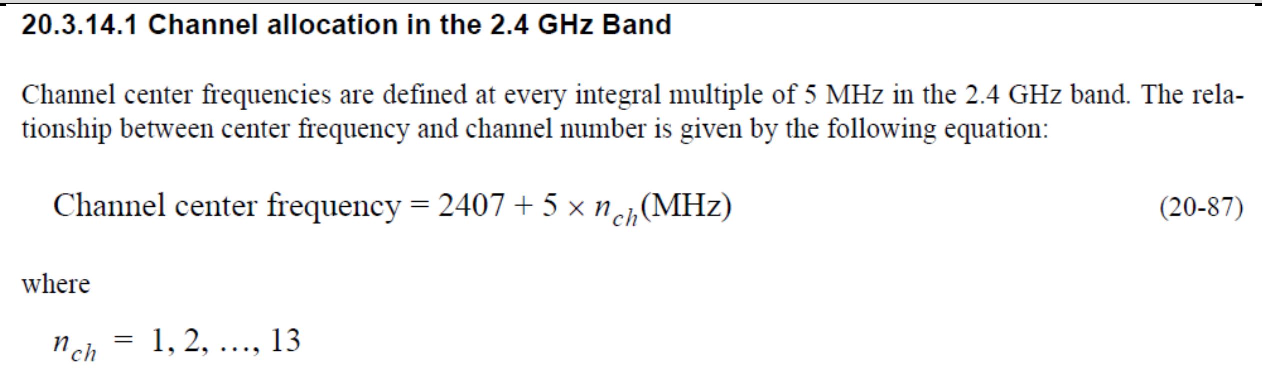
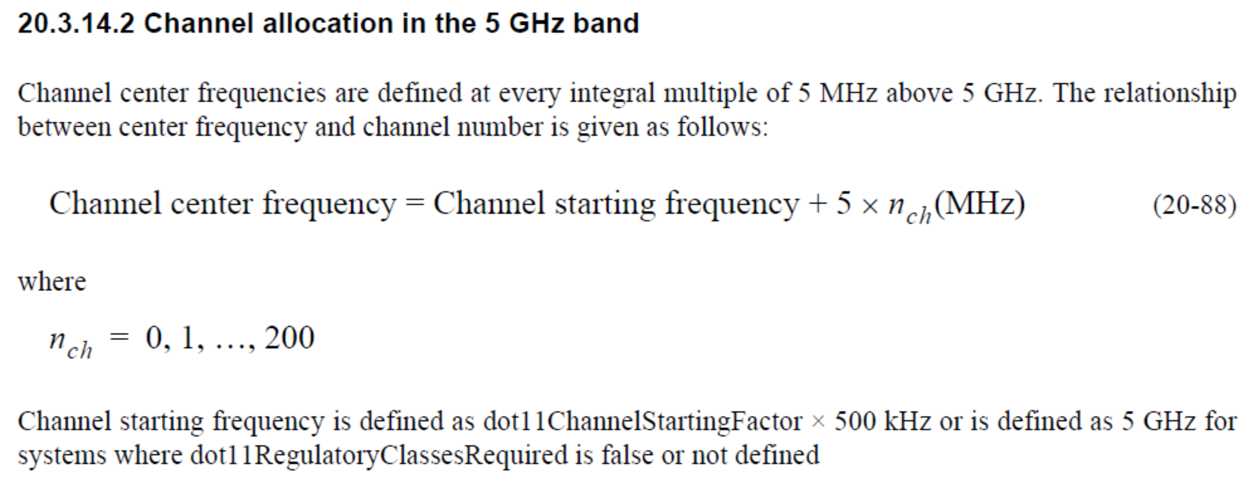
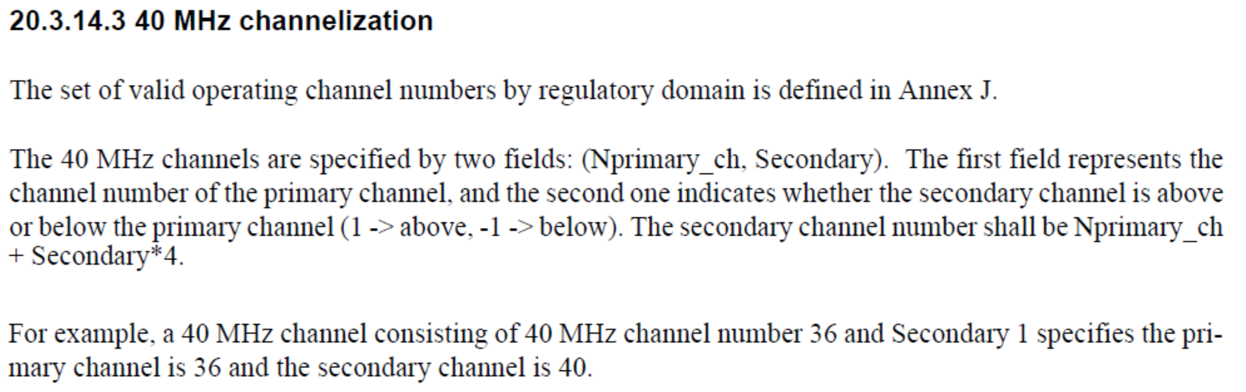
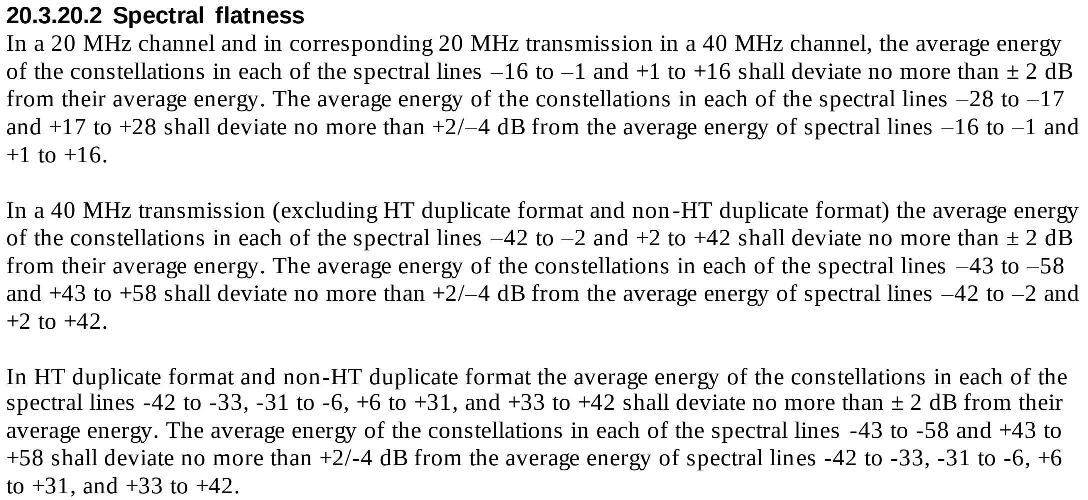
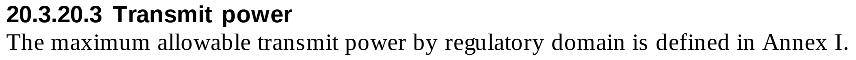
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r^{i_{TX}}_{LEG-DUP}(t-nT_{SYM}) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n}+p_nP_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T^{i_{TX}}_{CS}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz}) \quad (20\text{-}87)$ where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz}) \quad (20\text{-}88)$ where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3  **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2  **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

Claim 14 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.20.3

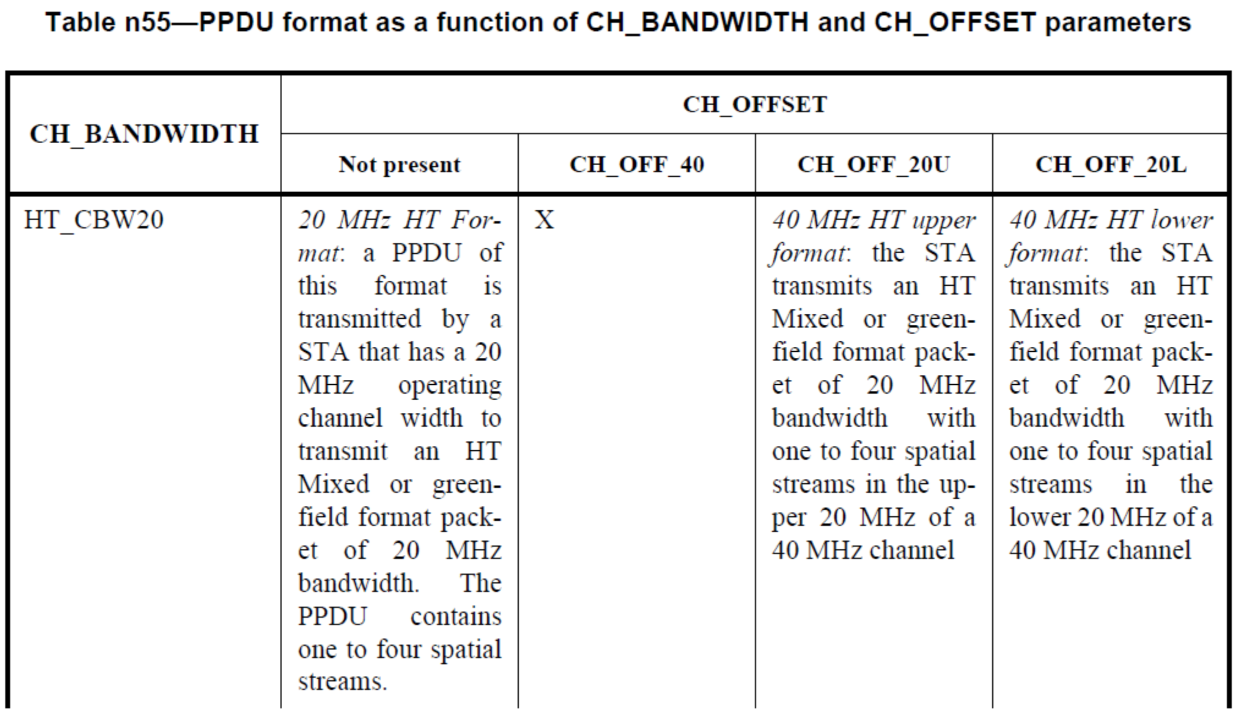
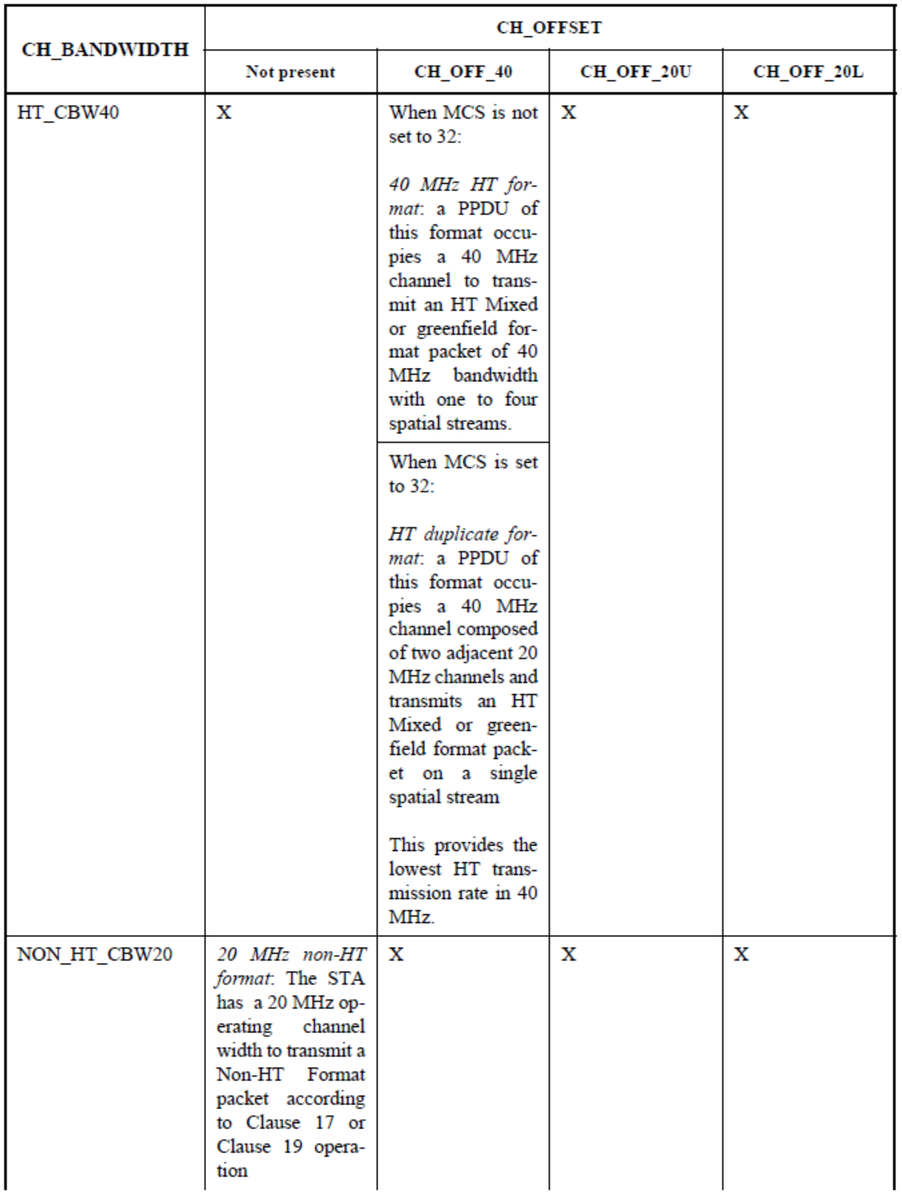


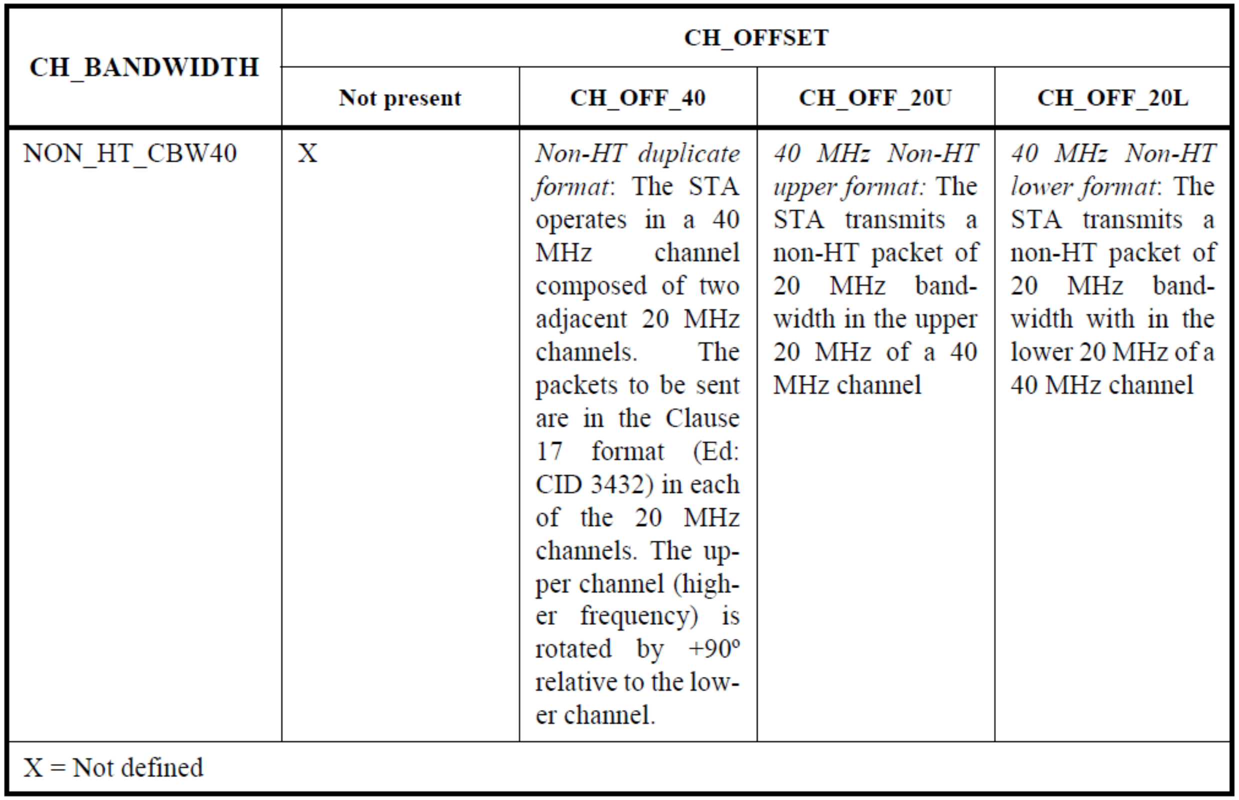
Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

CH_BANDWIDTH	**CH_OFFSET**			
	Not present	**CH_OFF_40**	**CH_OFF_20U**	**CH_OFF_20L**
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or green-field format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or green-field format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or green-field format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel



CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

Claim 14 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**



CH_BANDWIDTH	**CH_OFFSET**			
	Not present	**CH_OFF_40**	**CH_OFF_20U**	**CH_OFF_20L**
NON_HT_CBW40	X	*Non-HT duplicate format*: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.	*40 MHz Non-HT upper format:* The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel	*40 MHz Non-HT lower format*: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel
X = Not defined				

See, e.g., 802.11n D2.0 Table n55

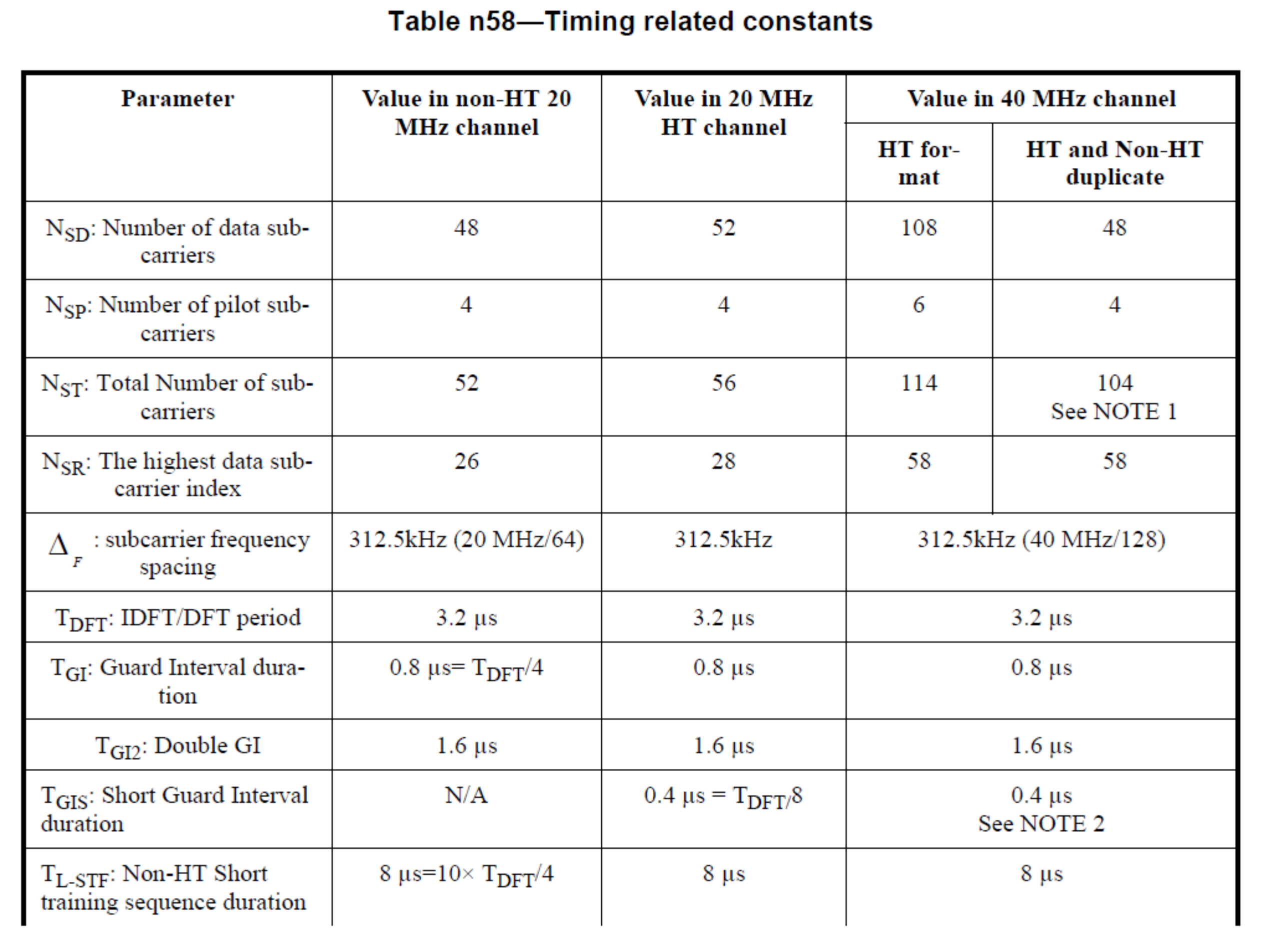
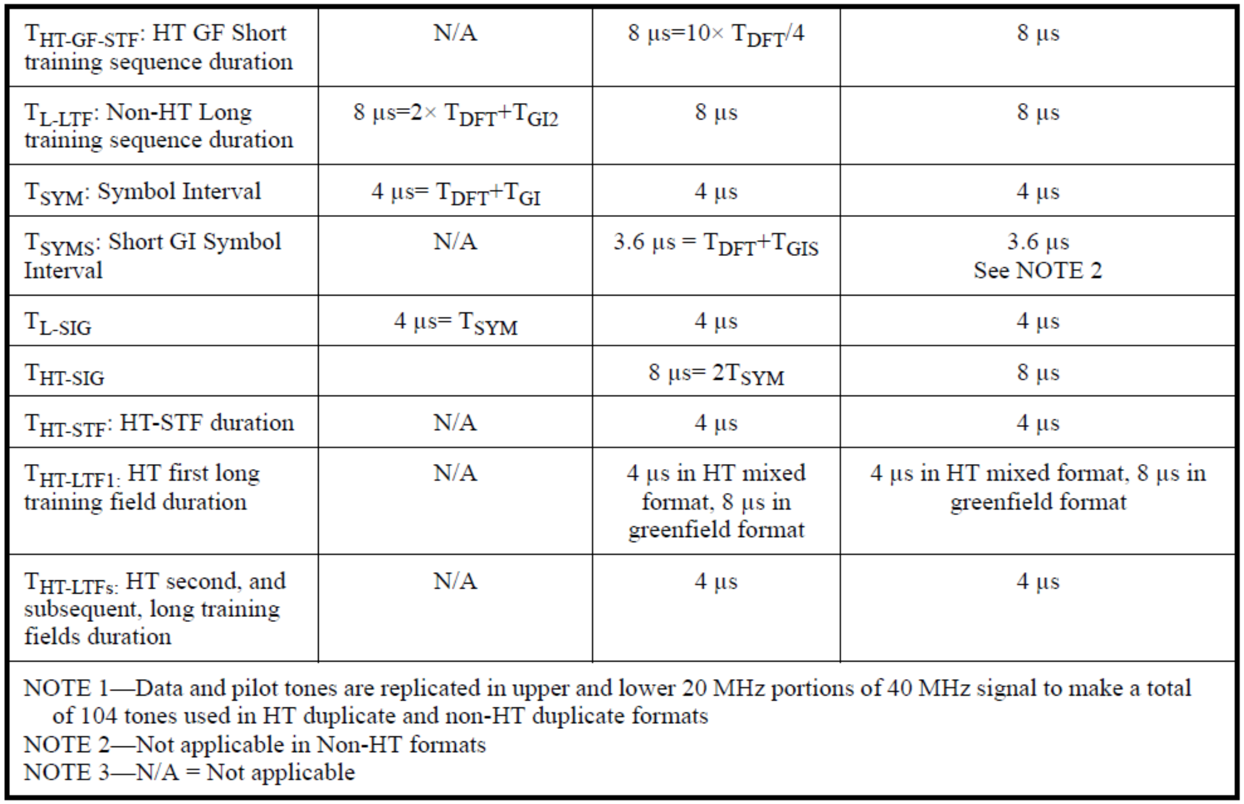
Claim 14 of the '802 Patent	**Prior Art Reference – 802.11n D2.0**
	

Table n58—Timing related constants

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

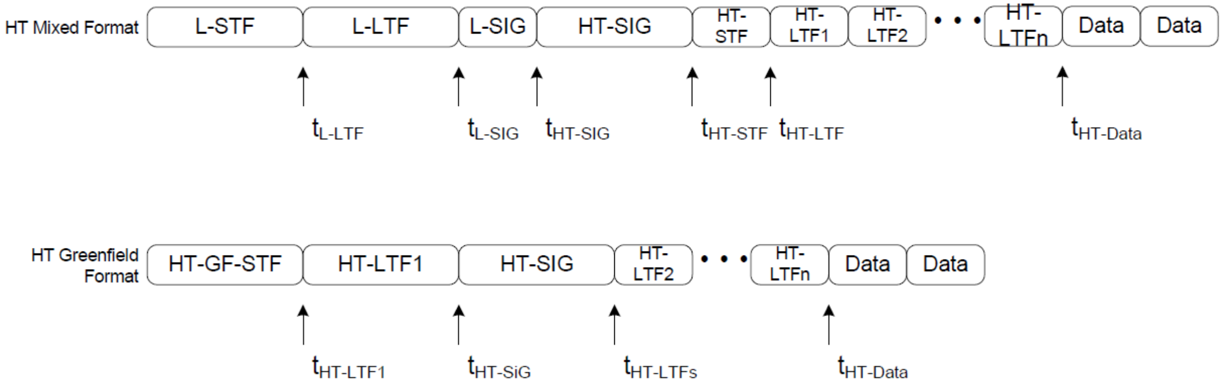
Claim 14 of the '802 Patent	**Prior Art Reference – 802.11n D2.0**



$T_{HT\text{-}GF\text{-}STF}$: HT GF Short training sequence duration	N/A	8 μs=10× T_{DFT}/4	8 μs
$T_{L\text{-}LTF}$: Non-HT Long training sequence duration	8 μs=2× $T_{DFT}+T_{GI2}$	8 μs	8 μs
T_{SYM}: Symbol Interval	4 μs= $T_{DFT}+T_{GI}$	4 μs	4 μs
T_{SYMS}: Short GI Symbol Interval	N/A	3.6 μs = $T_{DFT}+T_{GIS}$	3.6 μs See NOTE 2
$T_{L\text{-}SIG}$	4 μs= T_{SYM}	4 μs	4 μs
$T_{HT\text{-}SIG}$		8 μs= 2T_{SYM}	8 μs
$T_{HT\text{-}STF}$: HT-STF duration	N/A	4 μs	4 μs
$T_{HT\text{-}LTF1}$: HT first long training field duration	N/A	4 μs in HT mixed format, 8 μs in greenfield format	4 μs in HT mixed format, 8 μs in greenfield format
$T_{HT\text{-}LTFs}$: HT second, and subsequent, long training fields duration	N/A	4 μs	4 μs

NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable

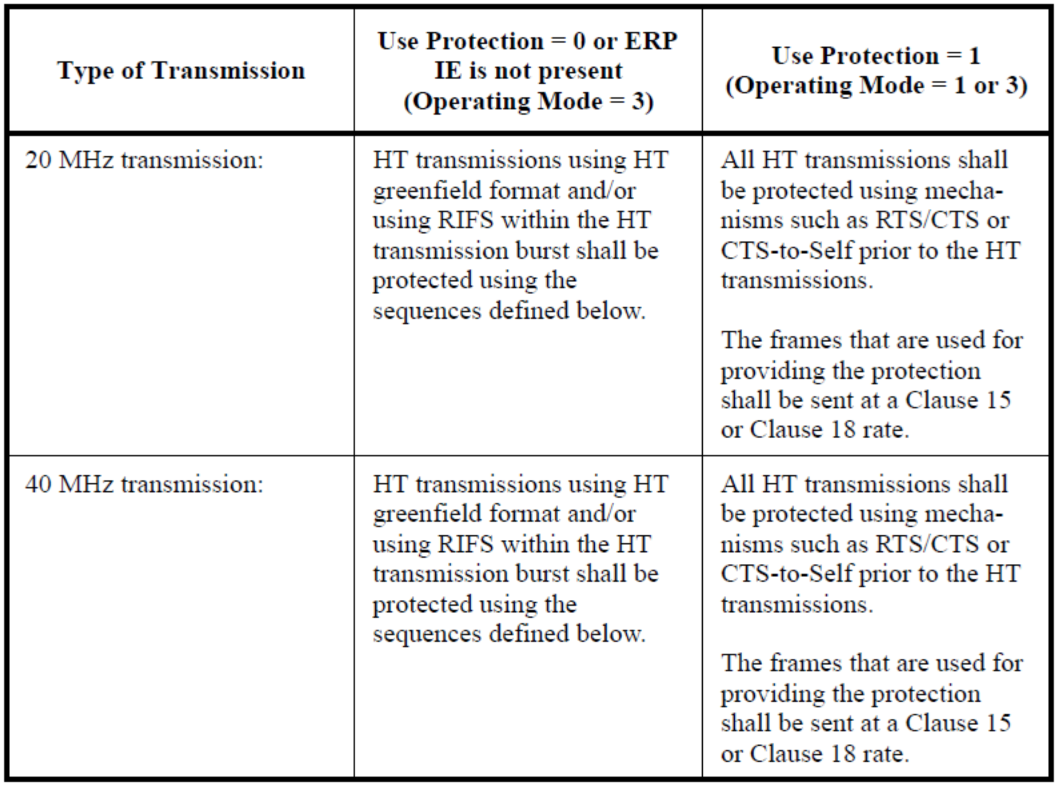
See, e.g., 802.11n D2.0 Table n58

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.
[14.4] amplifying the received signal in a low noise amplifier resulting in an amplified received up-converted signal, wherein the bandwidth of said low noise amplifier is greater than the difference between the lowest frequency in the	802.11n D2.0 discloses “amplifying the received signal in a low noise amplifier resulting in an amplified received up-converted signal, wherein the bandwidth of said low noise amplifier is greater than the difference between the lowest frequency in the first up-converted frequency range and the highest frequency in the second up-converted frequency range.” See, e.g.: **high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19

Claim 14 of the '802 Patent	Prior Art Reference – 802.11n D2.0
first up-converted frequency range and the highest frequency in the second up-converted frequency range;	**non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

Claim 14 of the '802 Patent	Prior Art Reference – 802.11n D2.0

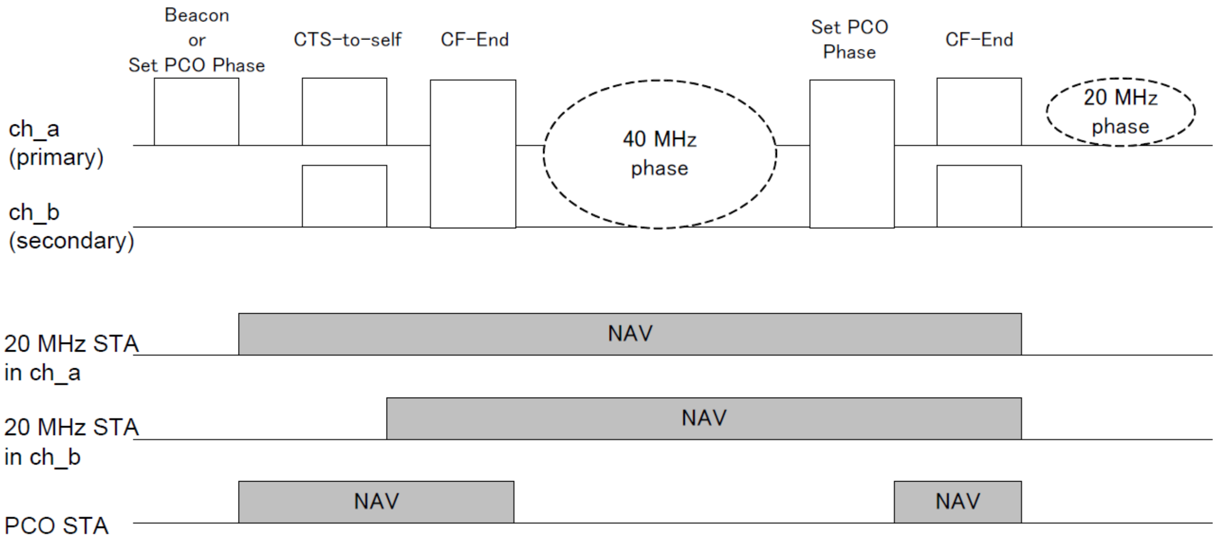
Table n49—Protection requirements for Operating Modes of 1 and 3



Type of Transmission	Use Protection = 0 or ERP IE is not present (Operating Mode = 3)	Use Protection = 1 (Operating Mode = 1 or 3)
20 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.
40 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.
NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

Claim 14 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 14 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $$r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t \right) \right\} \qquad (20\text{-}1)$$ where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

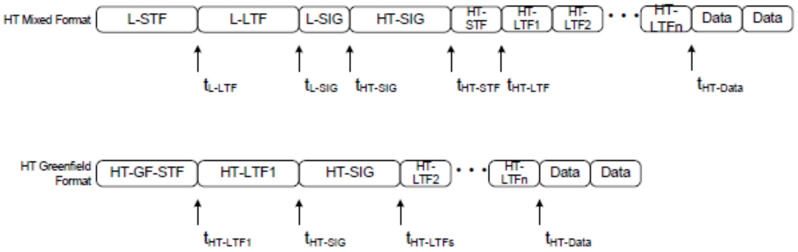


Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) \;=\; & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right) T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}\left(t - t_{HT-DATA}\right) \end{aligned} \qquad (20\text{-}2)$$

where

$$t_{L-LTF} = T_{L-STF}$$

$$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$$

$$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$$

$$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1}) \\ & + r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2)T_{HT-LTFs}) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \tag{20-3}$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\text{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\text{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j2\pi k \Delta_F t) \tag{20-4}$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \tag{20-5}$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \tag{20-6}$$

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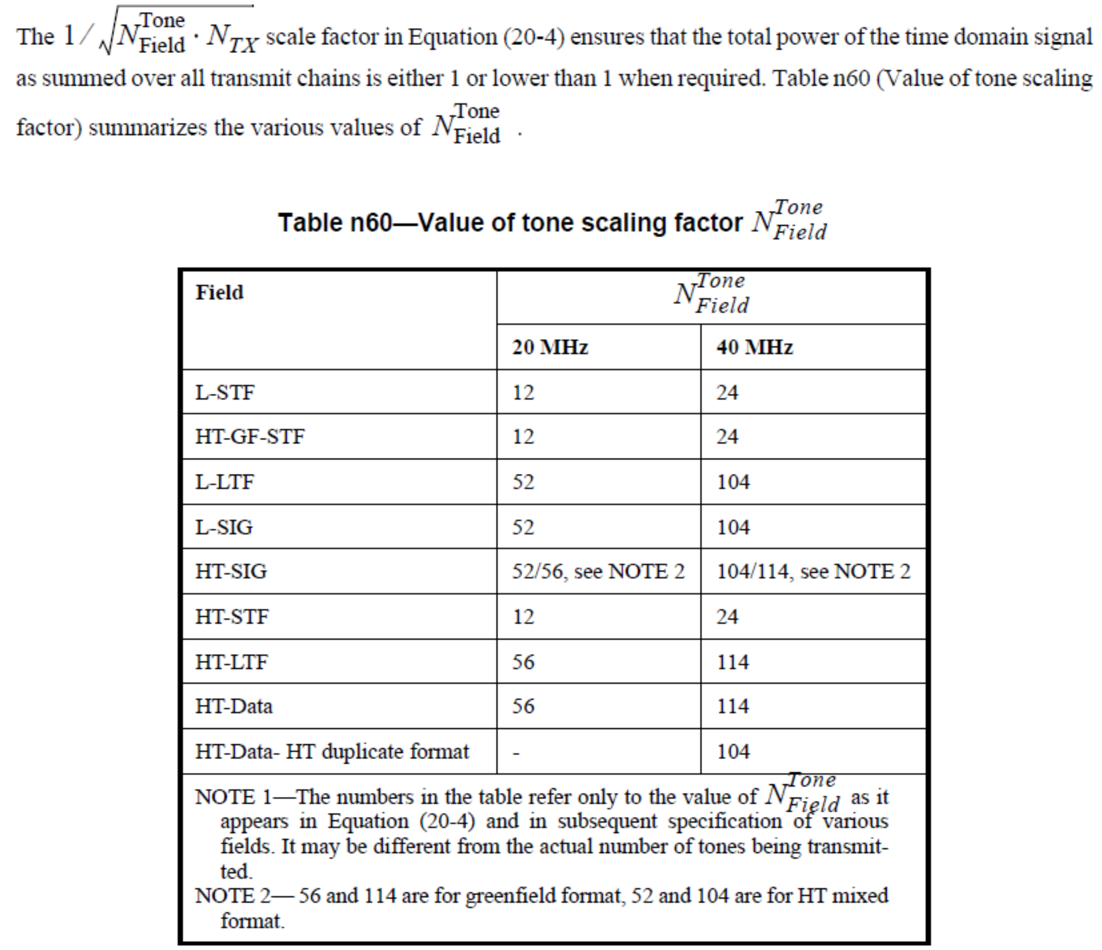

The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	40 MHz
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

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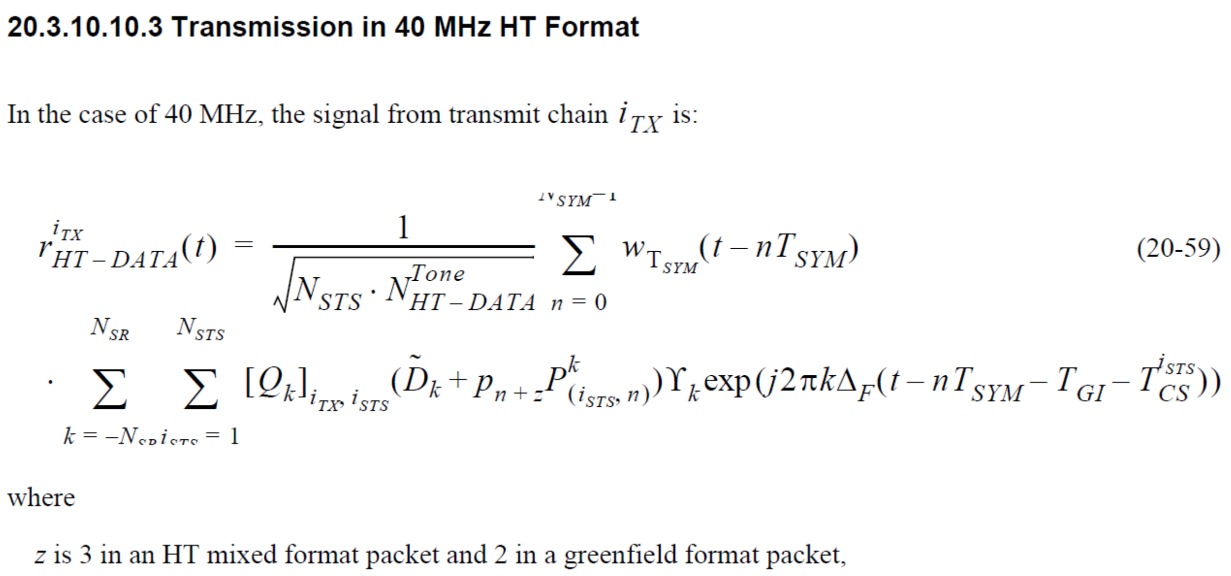
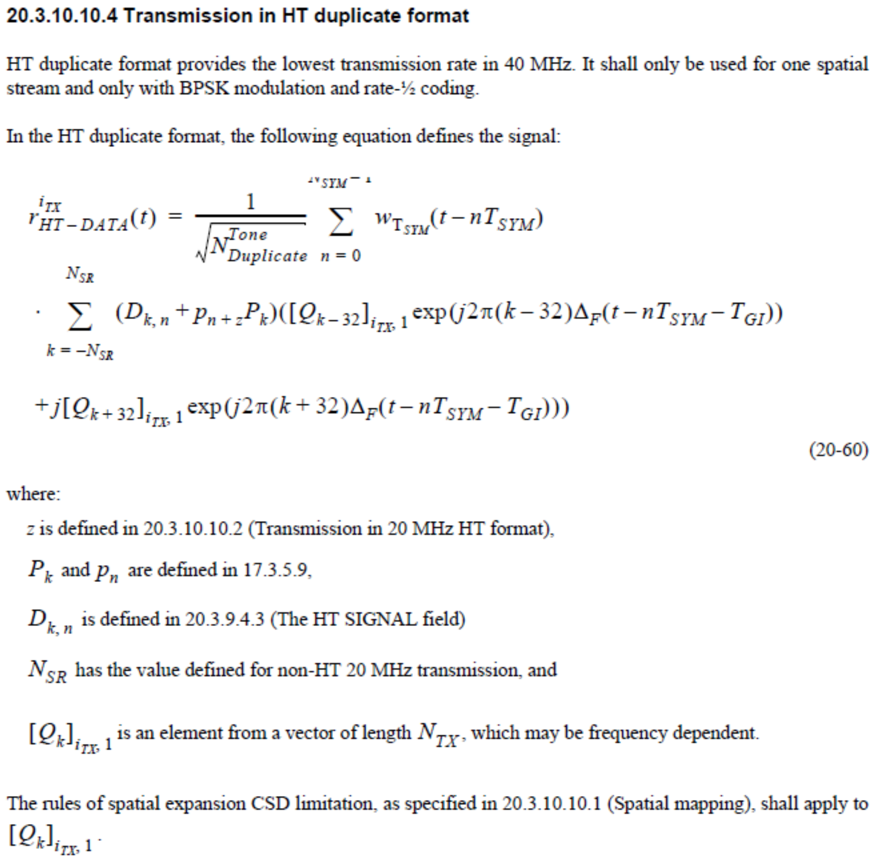
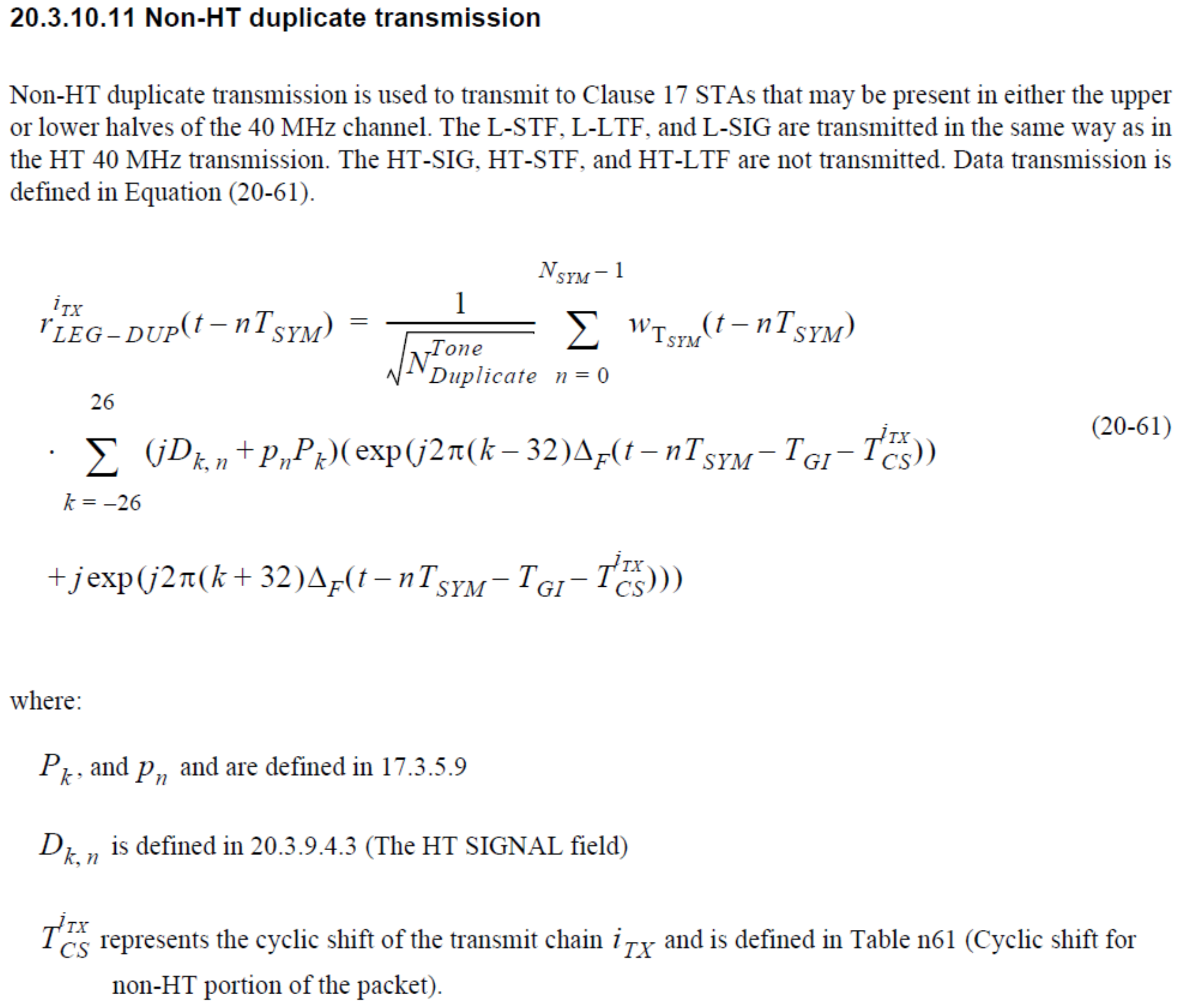
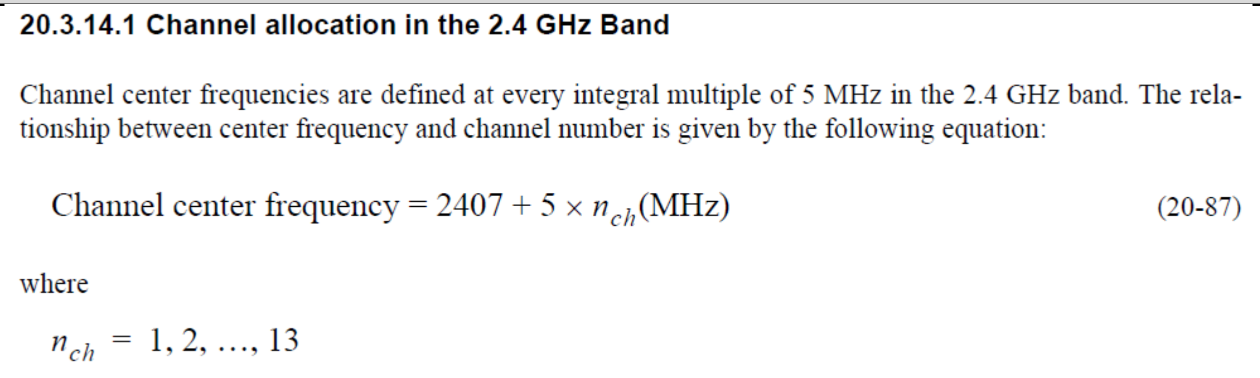
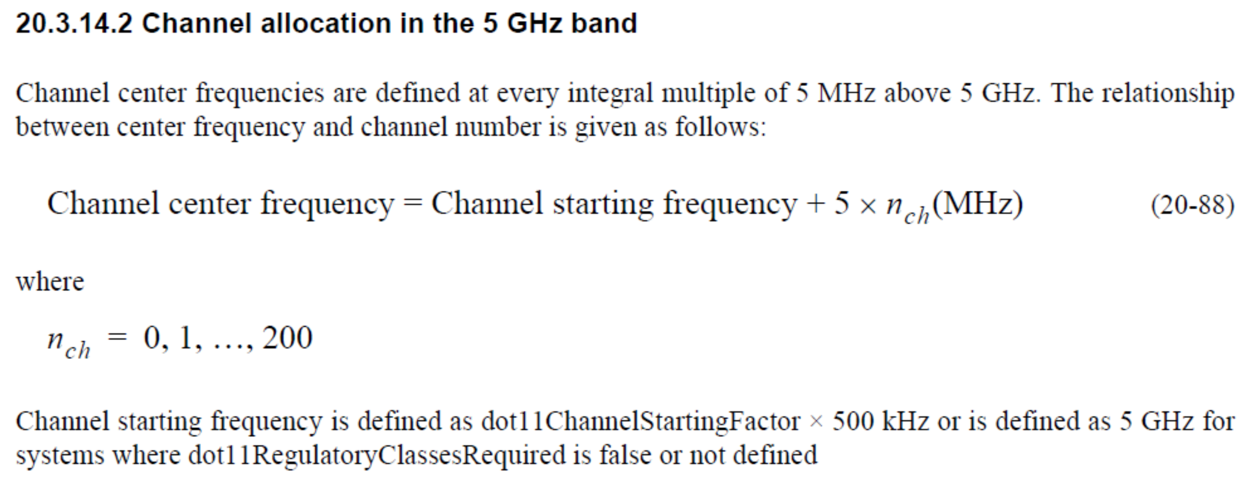
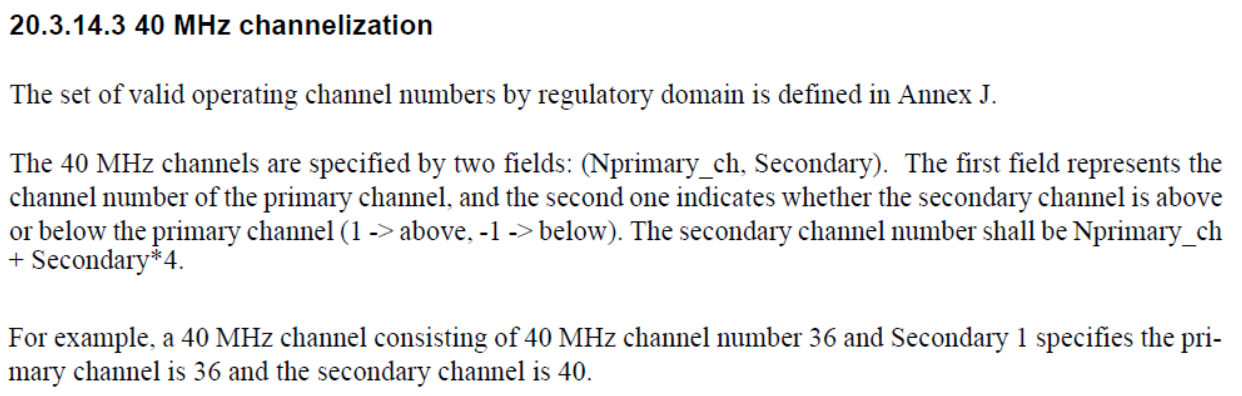
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P_{(i_{STS}, n)}^{k}) \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (20-58) where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P^k_{(i_{STS}, n)}) \Upsilon_k \exp(j 2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (20-59) where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n}+p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI})) + j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r^{i_{TX}}_{LEG-DUP}(t-nT_{SYM}) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}}\sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26}(jD_{k,n}+p_nP_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T^{i_{TX}}_{CS}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz}) \quad (20\text{-}87)$ where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz}) \quad (20\text{-}88)$ where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

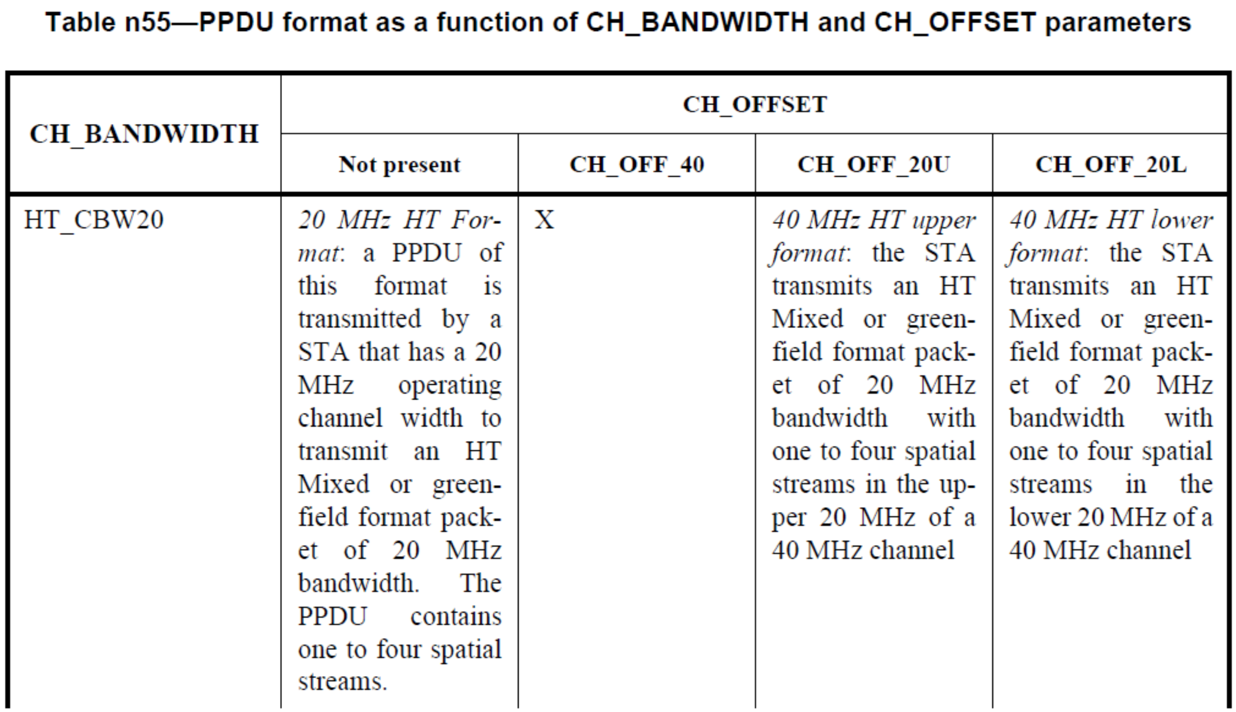
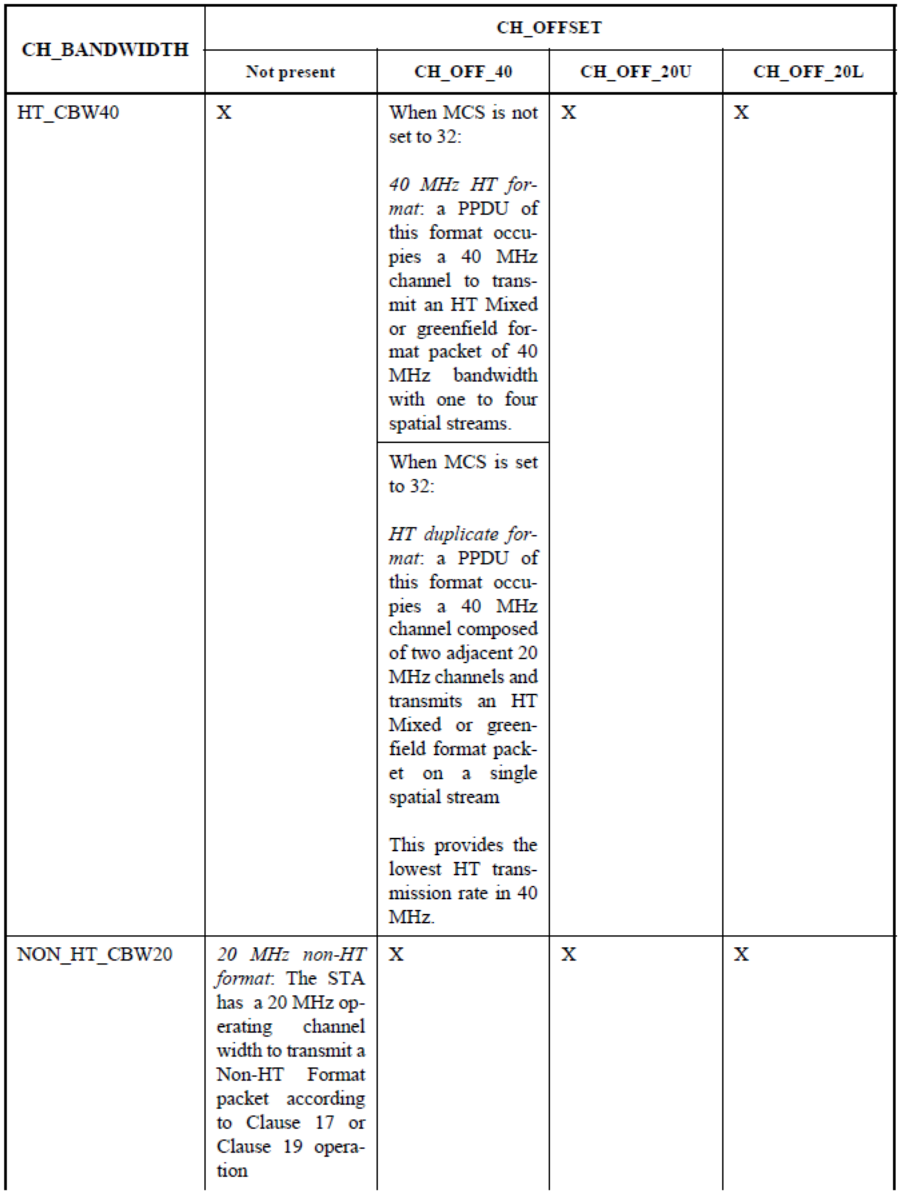
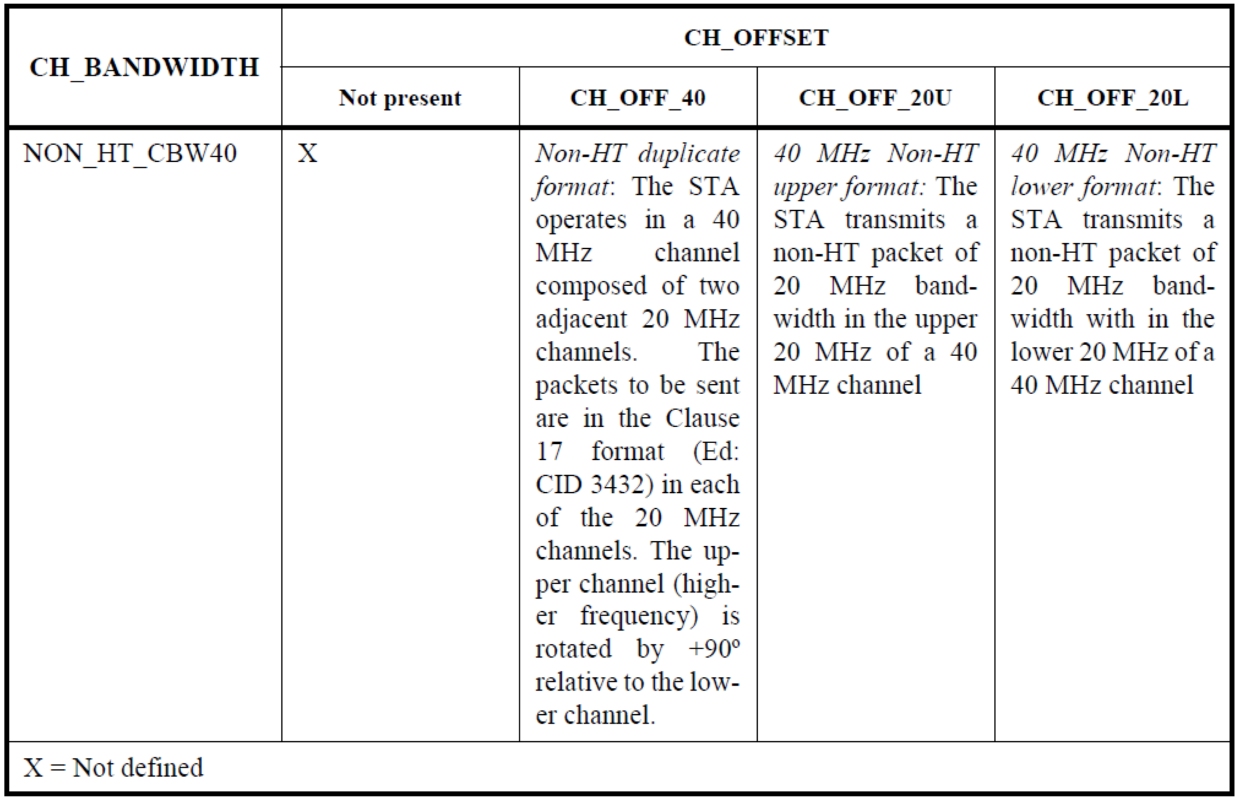
Claim 14 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.20.3 

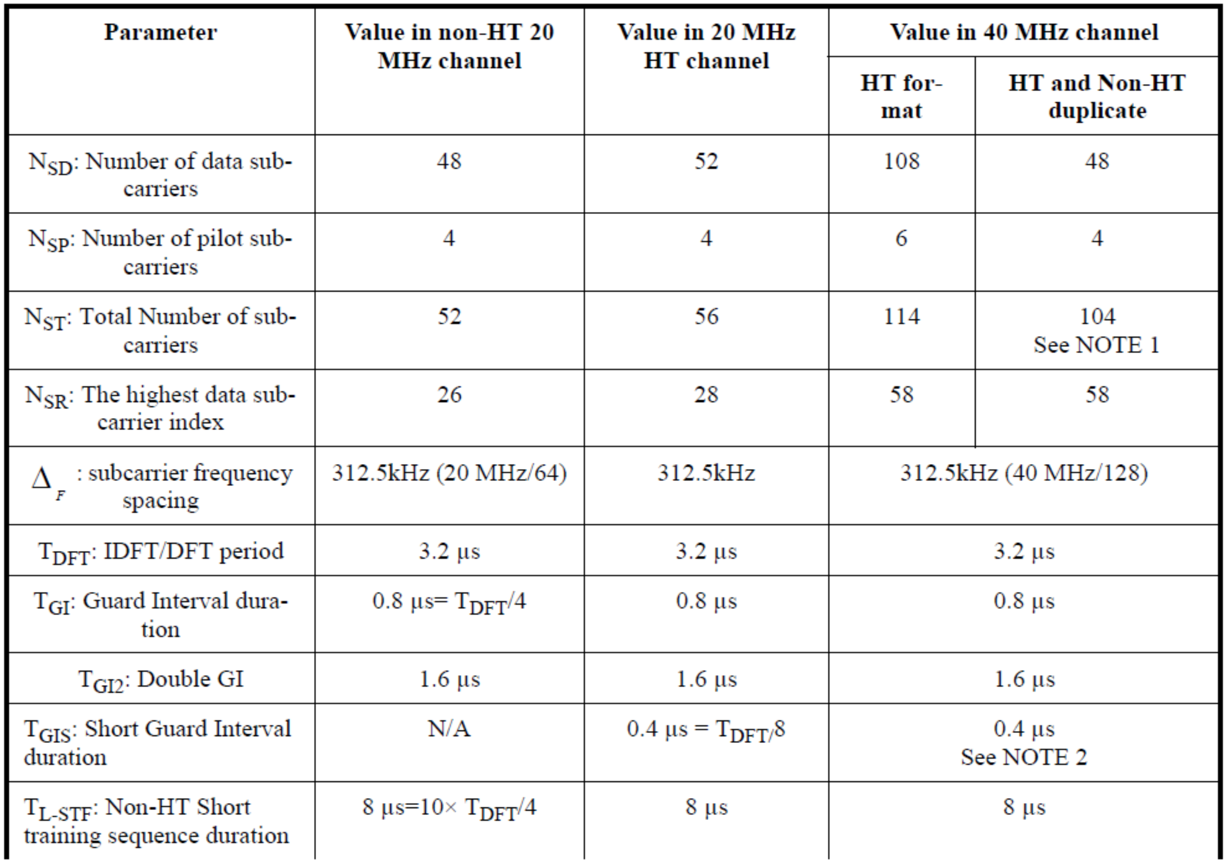
Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel



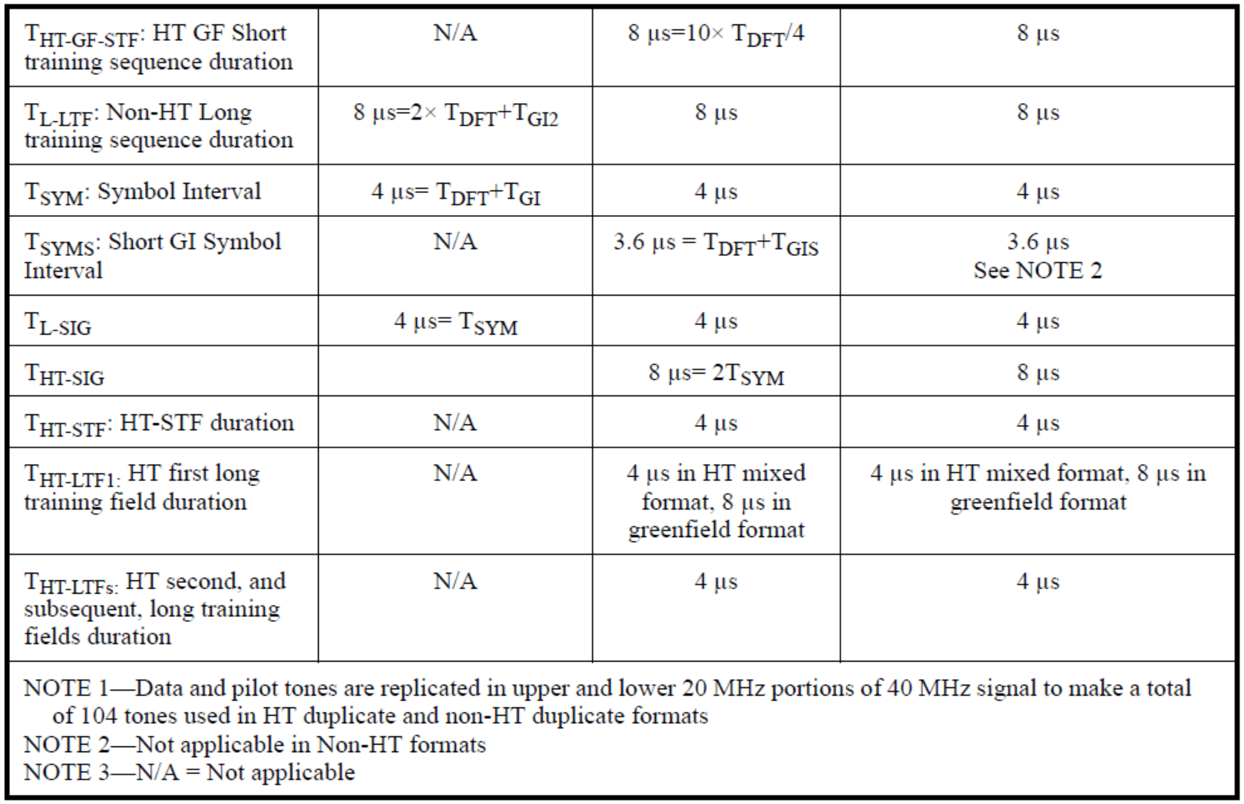
CH_BANDWIDTH	**CH_OFFSET**			
	Not present	**CH_OFF_40**	**CH_OFF_20U**	**CH_OFF_20L**
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

<table>
<tr><th>Claim 14 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>NON_HT_CBW40</td><td>X</td><td>*Non-HT duplicate format*: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.</td><td>*40 MHz Non-HT upper format:* The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel</td><td>*40 MHz Non-HT lower format*: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel</td></tr>
<tr><td colspan="5">X = Not defined</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n55
</td></tr>
</table>

Claim 14 of the '802 Patent	**Prior Art Reference – 802.11n D2.0**
	Table n58—Timing related constants 

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

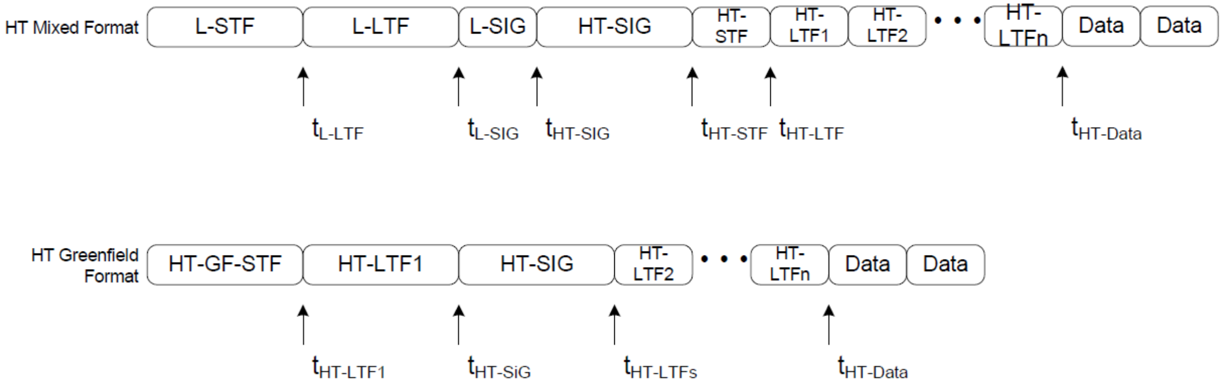
Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0



$T_{HT\text{-}GF\text{-}STF}$: HT GF Short training sequence duration	N/A	8 µs=10× $T_{DFT}/4$	8 µs
$T_{L\text{-}LTF}$: Non-HT Long training sequence duration	8 µs=2× $T_{DFT}+T_{GI2}$	8 µs	8 µs
T_{SYM}: Symbol Interval	4 µs= $T_{DFT}+T_{GI}$	4 µs	4 µs
T_{SYMS}: Short GI Symbol Interval	N/A	3.6 µs = $T_{DFT}+T_{GIS}$	3.6 µs See NOTE 2
$T_{L\text{-}SIG}$	4 µs= T_{SYM}	4 µs	4 µs
$T_{HT\text{-}SIG}$		8 µs= $2T_{SYM}$	8 µs
$T_{HT\text{-}STF}$: HT-STF duration	N/A	4 µs	4 µs
$T_{HT\text{-}LTF1}$: HT first long training field duration	N/A	4 µs in HT mixed format, 8 µs in greenfield format	4 µs in HT mixed format, 8 µs in greenfield format
$T_{HT\text{-}LTFs}$: HT second, and subsequent, long training fields duration	N/A	4 µs	4 µs

NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable

See, e.g., 802.11n D2.0 Table n58

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.
[14.5] down-converting the amplified received up-converted signal using a first down-converter and a signal corresponding to the first RF center frequency to produce a fourth analog signal	802.11n D2.0 discloses “down-converting the amplified received up-converted signal using a first down-converter and a signal corresponding to the first RF center frequency to produce a fourth analog signal corresponding to the first analog signal.” See, e.g.: **high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
corresponding to the first analog signal; and	**non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

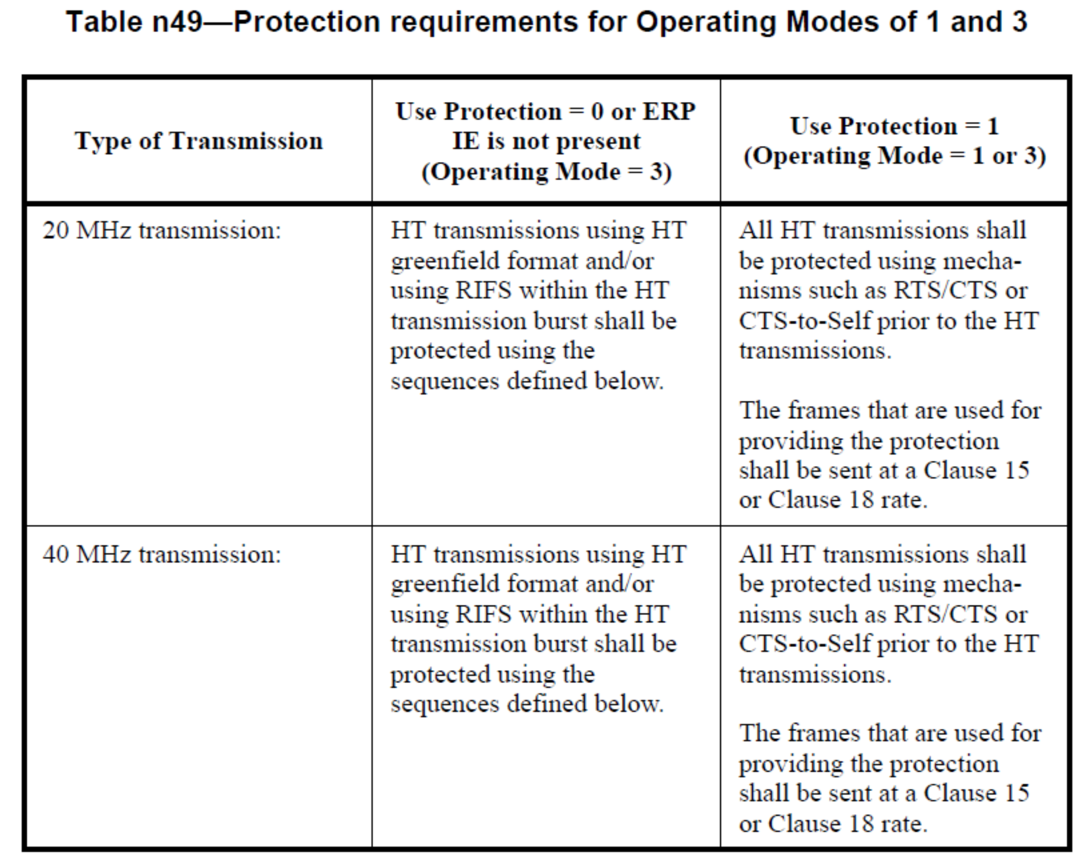
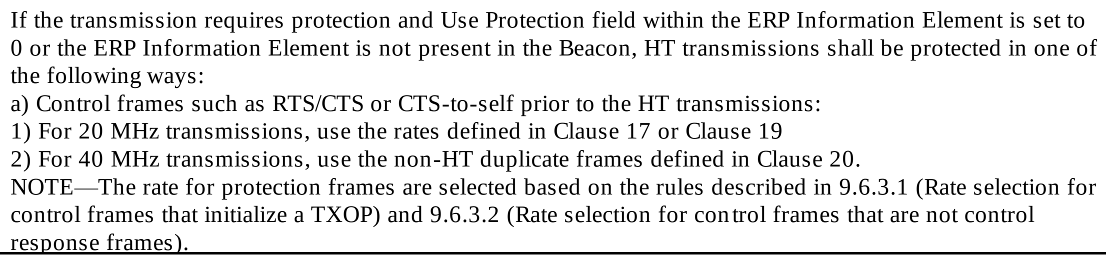
Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	

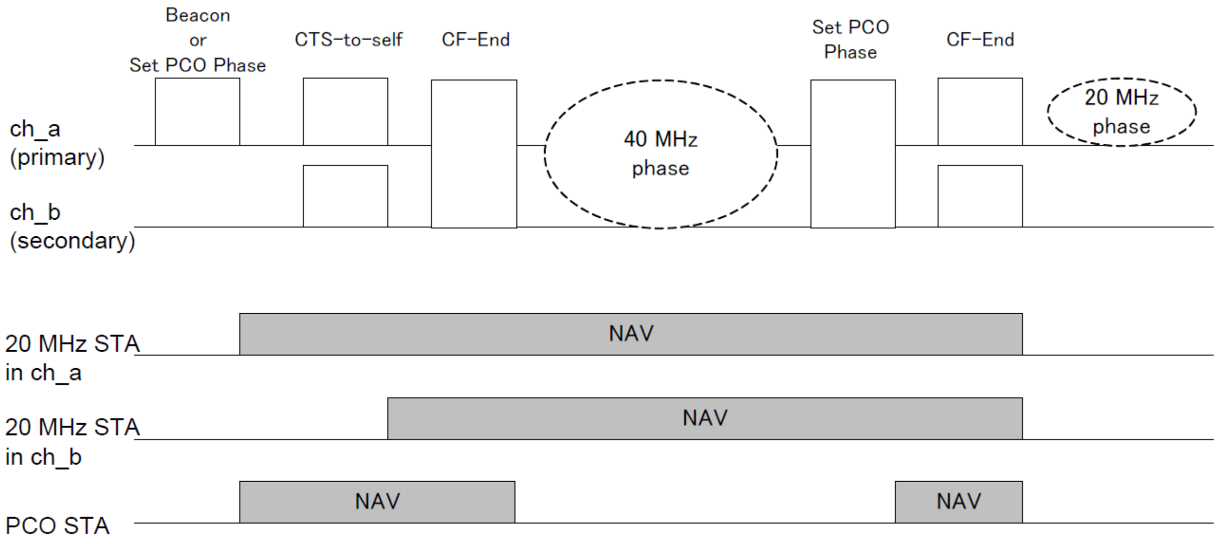
Table n49—Protection requirements for Operating Modes of 1 and 3

Type of Transmission	Use Protection = 0 or ERP IE is not present (Operating Mode = 3)	Use Protection = 1 (Operating Mode = 1 or 3)
20 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.
40 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.



If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.
NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).

Claim 14 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

<table>
<tr><th>Claim 14 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU.

During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel.

During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS.

A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS.

The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.</td></tr>
</table>

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

Claim 14 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\{r(t)\exp(j2\pi f_c t)\}$ (20-1) where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

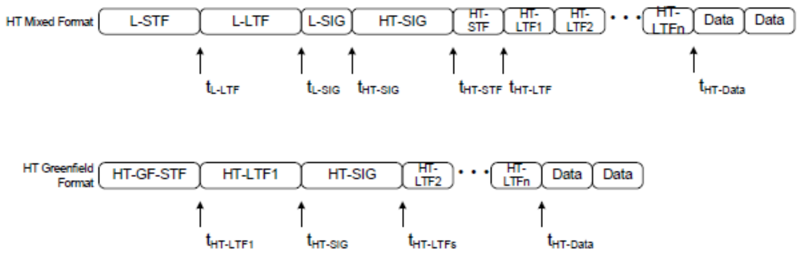


Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) &= r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ &+ r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ &+ r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ &+ r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ &+ \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right)T_{HT-LTFs}\right) \\ &+ r_{HT-DATA}^{(i_{TX})}\left(t - t_{HT-DATA}\right) \end{aligned} \tag{20-2}$$

where

$t_{L-LTF} = T_{L-STF}$

$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$

$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$

$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1}) \\ & + r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2) T_{HT-LTFs}) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \quad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\mathrm{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\mathrm{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\mathrm{Field}}^{\mathrm{Tone}} \cdot N_{TX}}} w_{\mathrm{T_{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j 2 \pi k \Delta_F t) \quad (20\text{-}4)$$

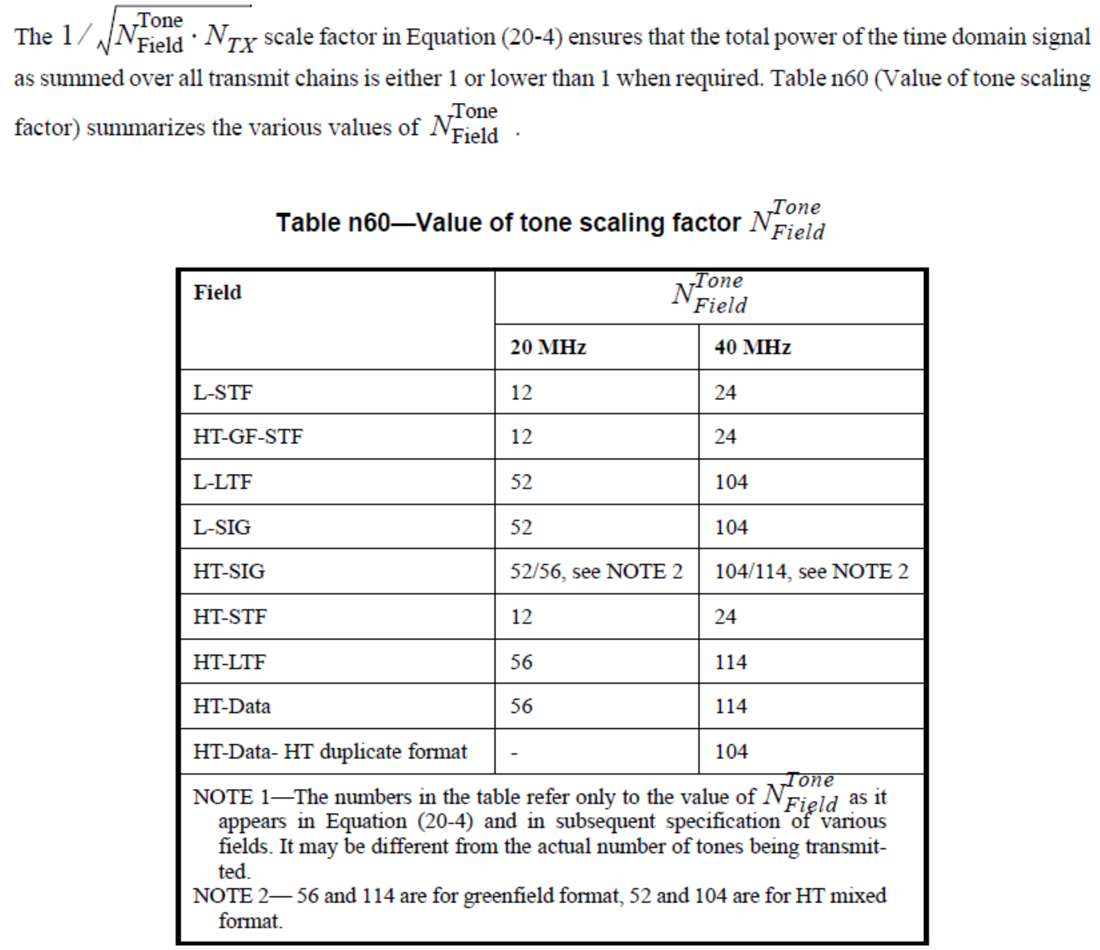
This general representation holds for all fields. A suggested definition of the windowing function , $w_{\mathrm{T_{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \quad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \quad (20\text{-}6)$$

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0



The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

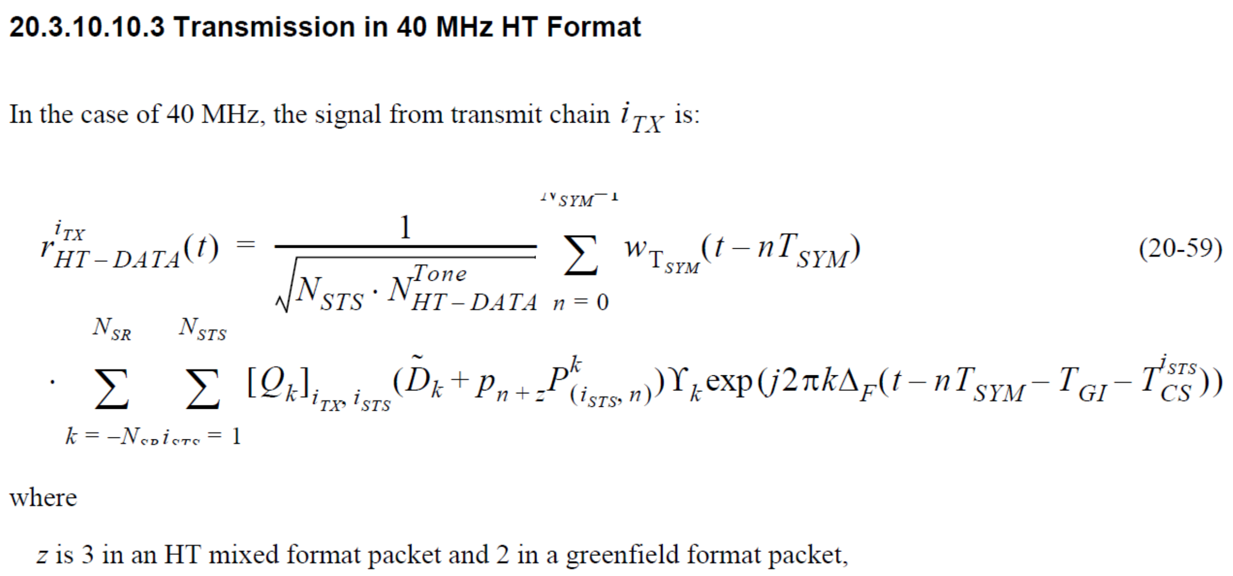
Field	N_{Field}^{Tone}	
	20 MHz	**40 MHz**
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

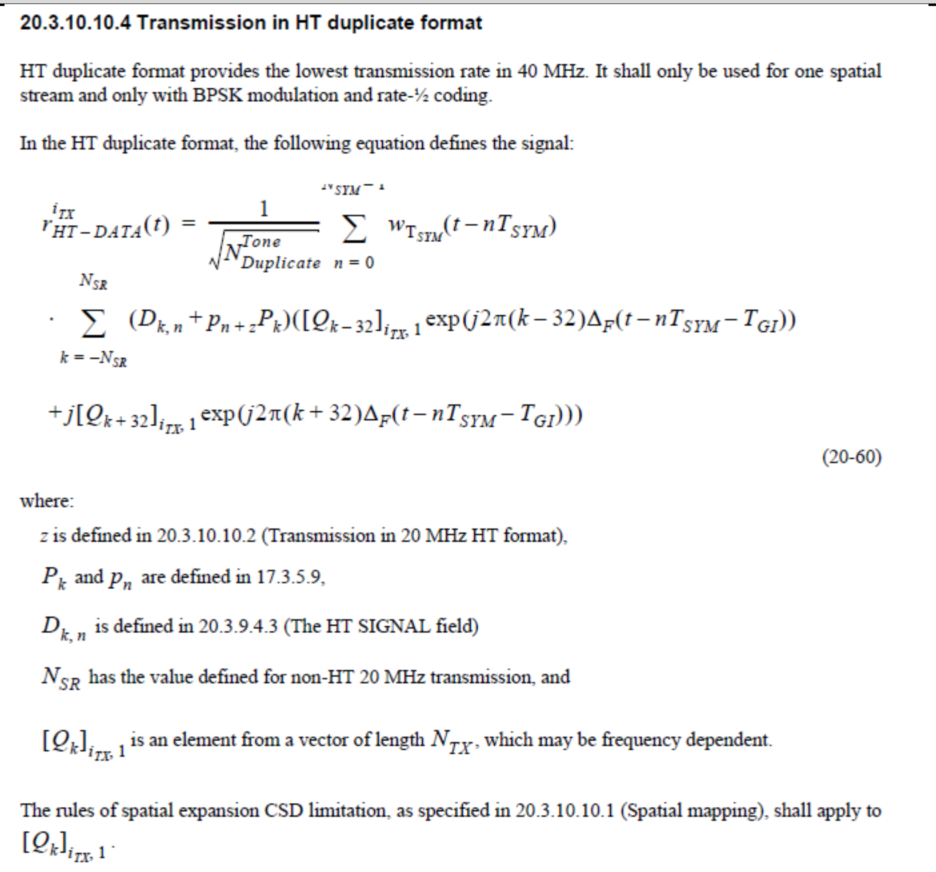
NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.
NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

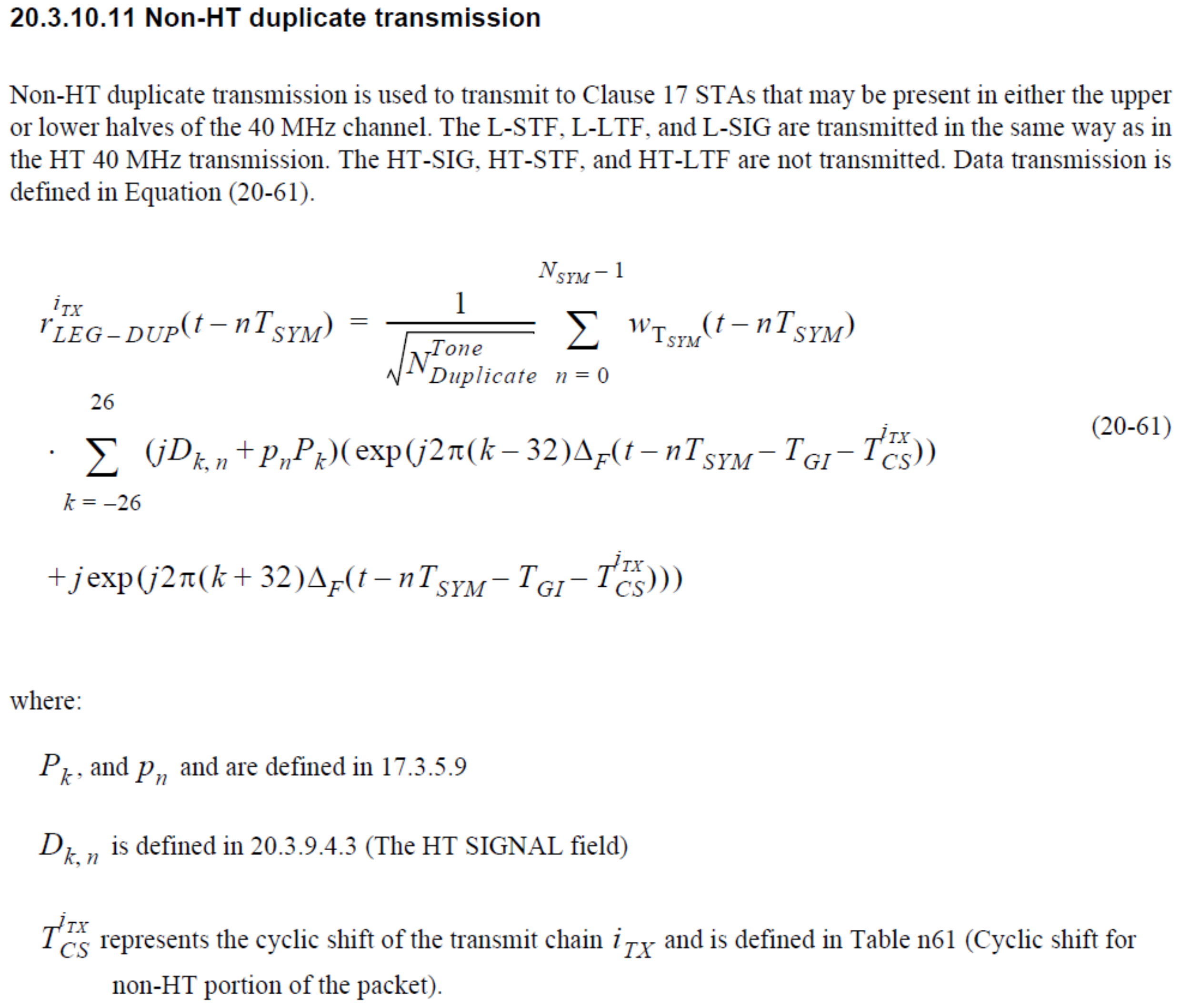
See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

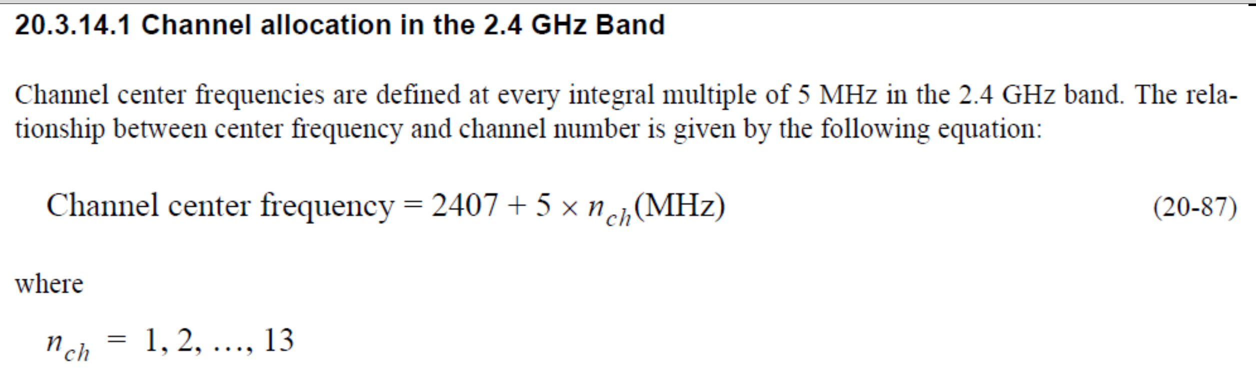
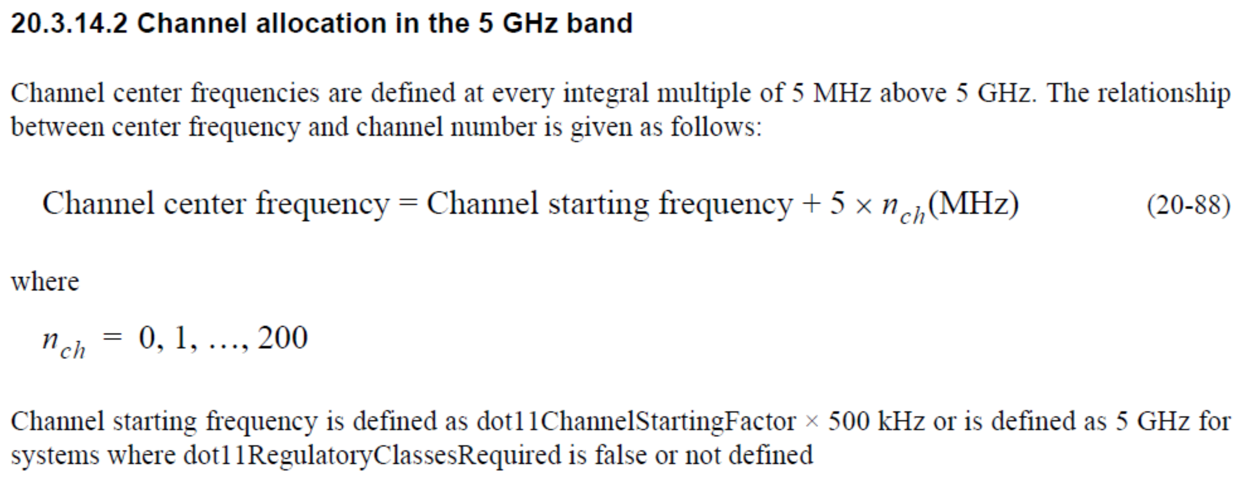
20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel
When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

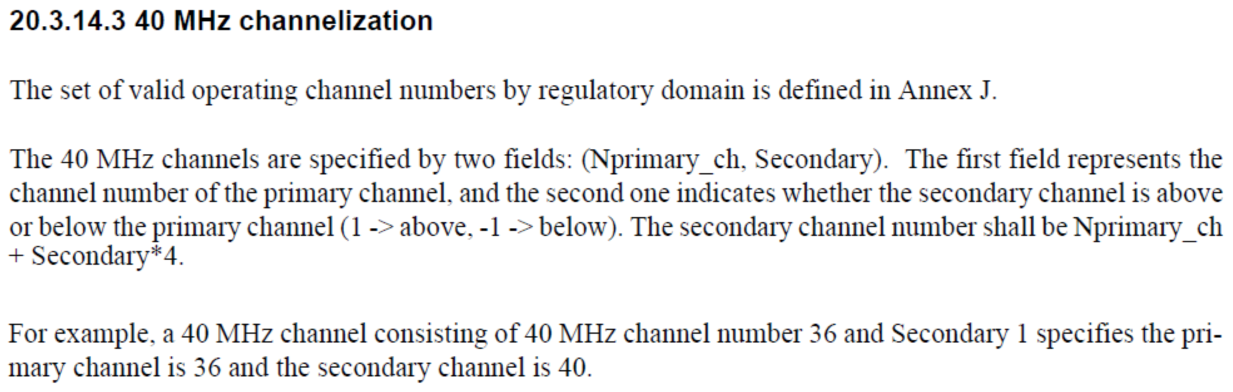
Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $$D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $$r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P_{(i_{STS},n)}^{k}) \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}})) \quad (20\text{-}58)$$ where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P_{(i_{STS}, n)}^k) \Upsilon_k \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (20-59) where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

Claim 14 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n}+p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1}\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI})) + j[Q_{k+32}]_{i_{TX},1}\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r^{i_{TX}}_{LEG-DUP}(t-nT_{SYM}) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n}+p_nP_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T^{i_{TX}}_{CS}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 14 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz}) \quad (20\text{-}87)$ where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz}) \quad (20\text{-}88)$ where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

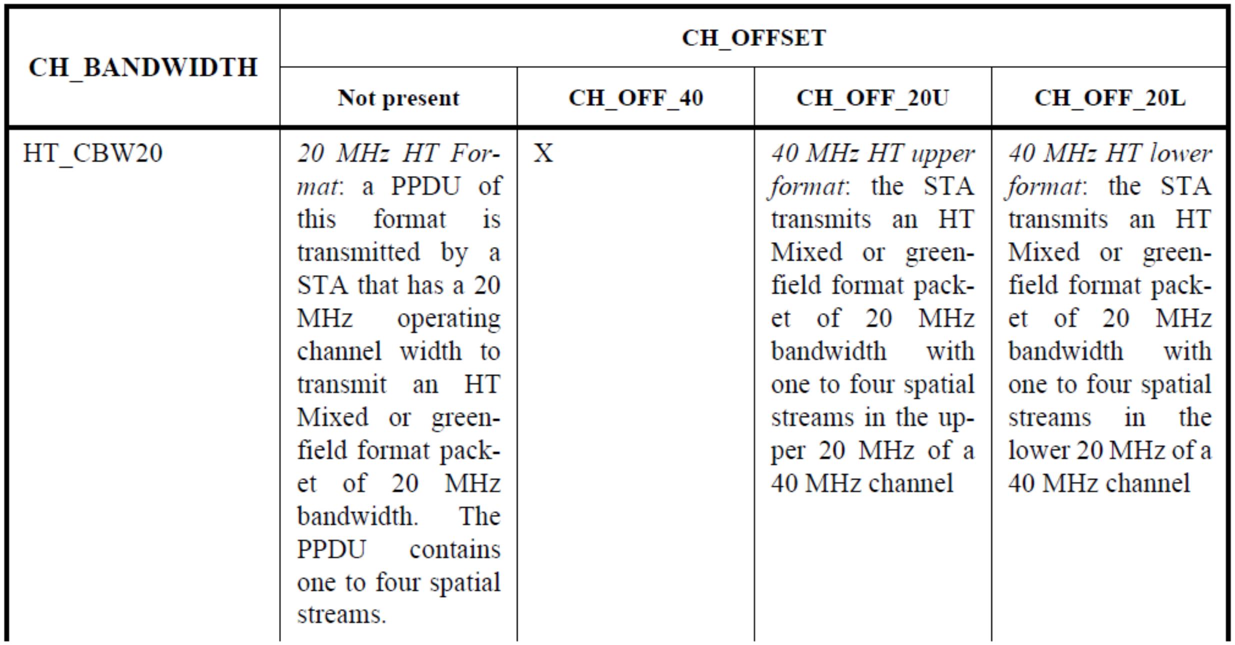
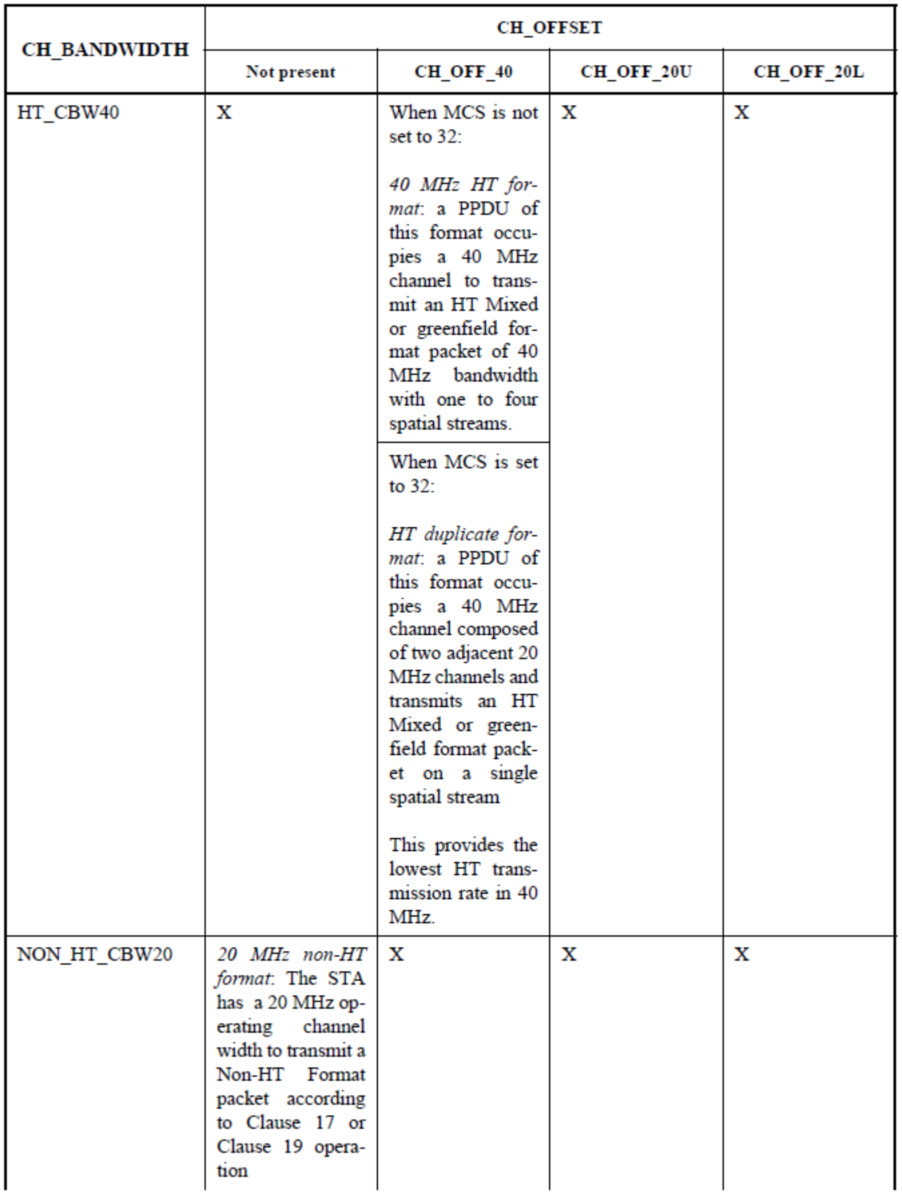
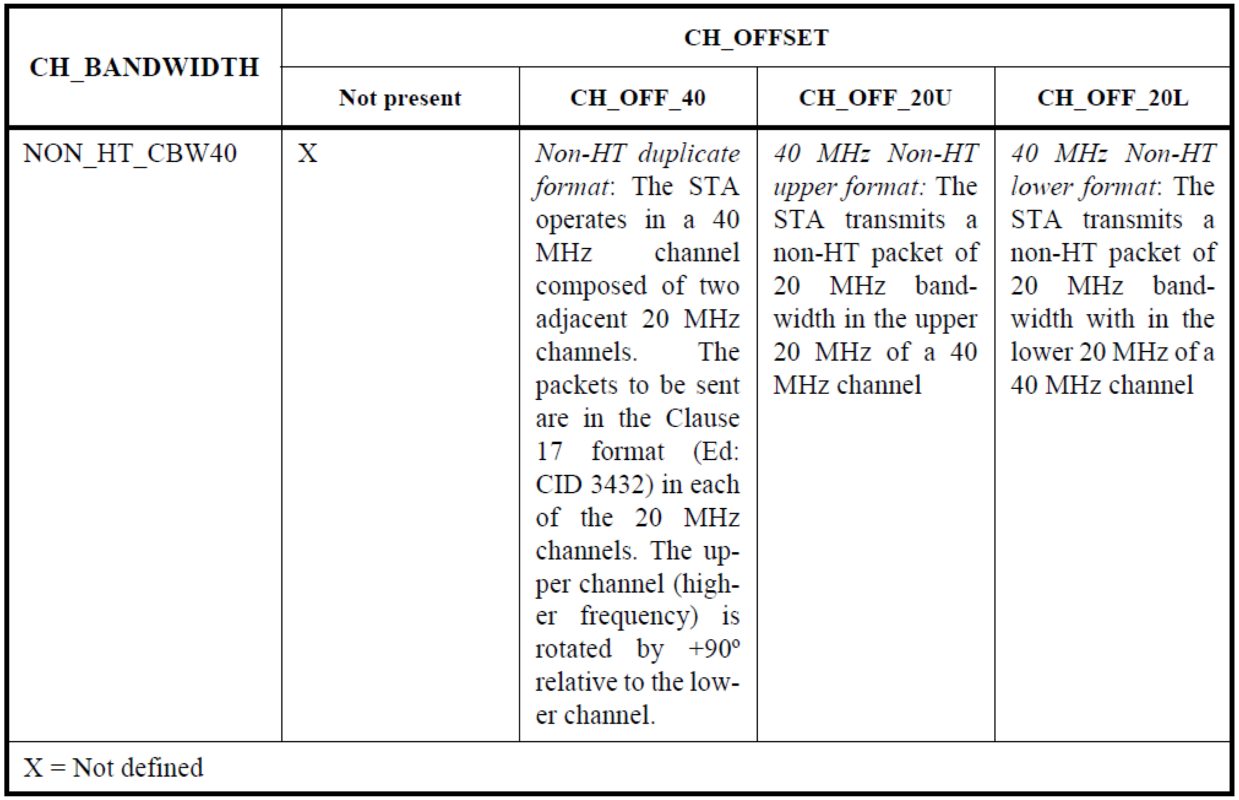
Claim 14 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.20.3 **Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters** 

Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

CH_BANDWIDTH	**CH_OFFSET**			
	Not present	**CH_OFF_40**	**CH_OFF_20U**	**CH_OFF_20L**
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel

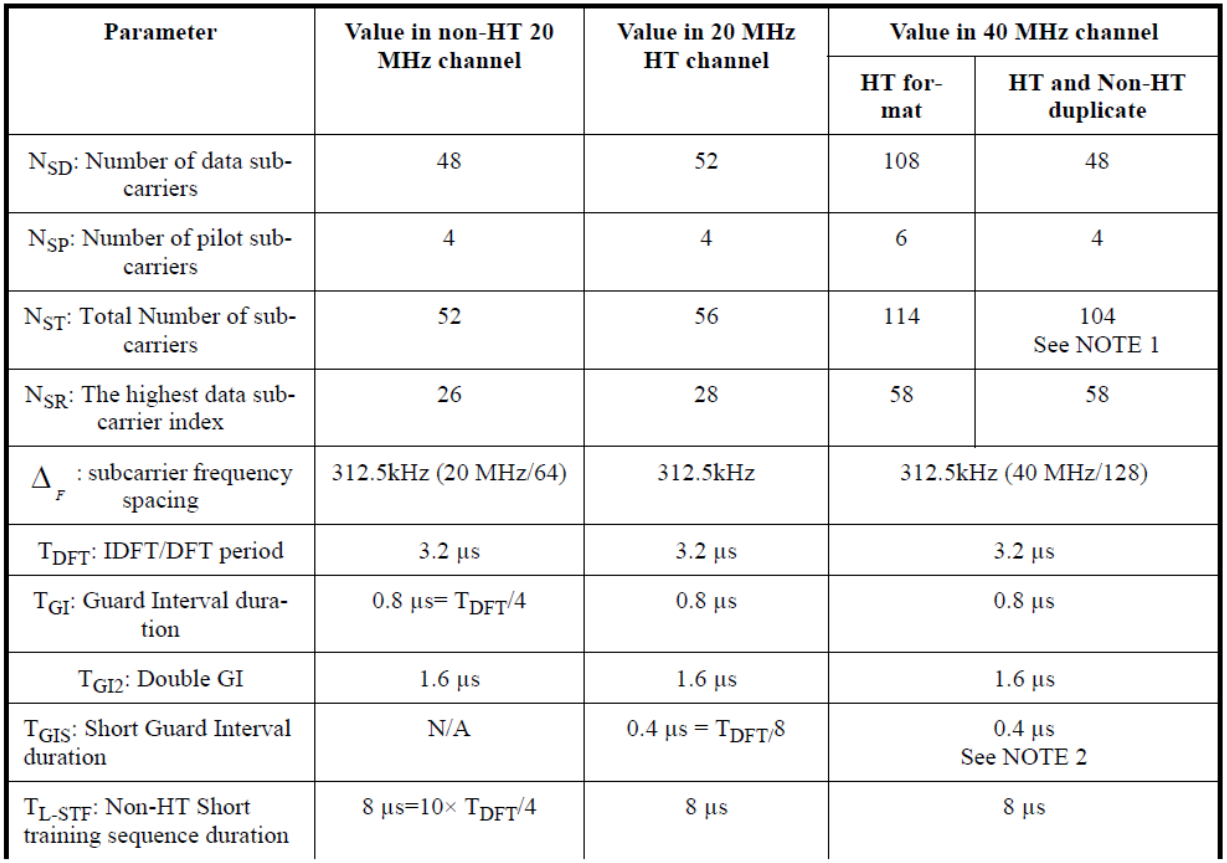


CH_BANDWIDTH	**CH_OFFSET**			
	Not present	**CH_OFF_40**	**CH_OFF_20U**	**CH_OFF_20L**
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams.	X	X
		When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.		
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

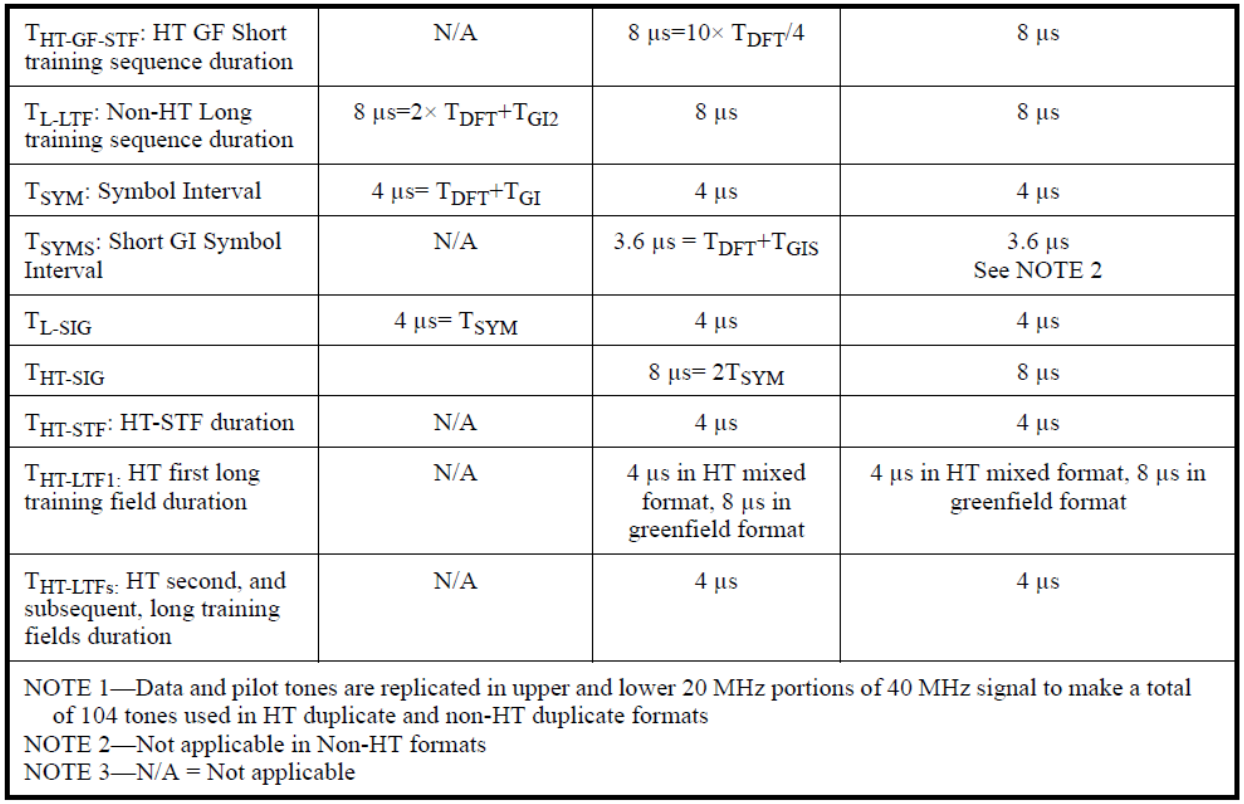
<table>
<tr><th>Claim 14 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>NON_HT_CBW40</td><td>X</td><td><i>Non-HT duplicate format</i>: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.</td><td><i>40 MHz Non-HT upper format:</i> The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel</td><td><i>40 MHz Non-HT lower format</i>: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel</td></tr>
<tr><td colspan="5">X = Not defined</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n55
</td></tr>
</table>

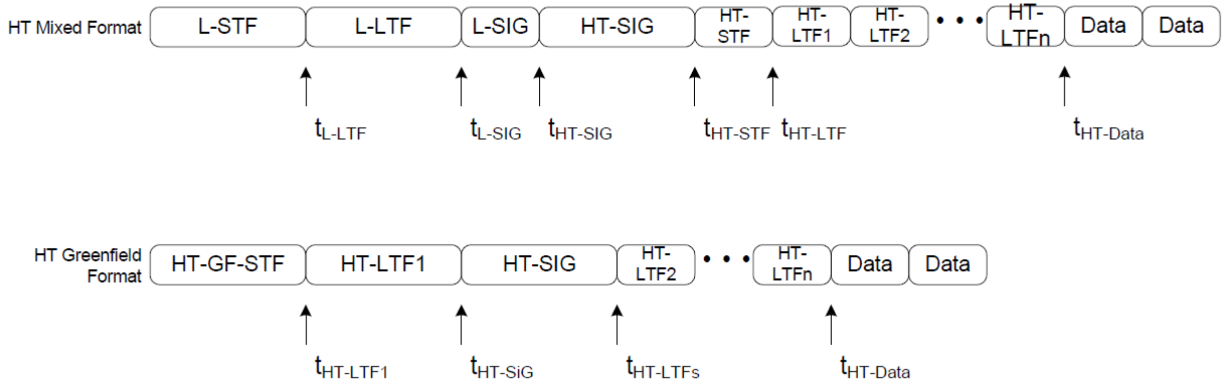
Claim 14 of the '802 Patent	Prior Art Reference – 802.11n D2.0

Table n58—Timing related constants



Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 μs	3.2 μs	3.2 μs	
T_{GI}: Guard Interval duration	0.8 μs= $T_{DFT}/4$	0.8 μs	0.8 μs	
T_{GI2}: Double GI	1.6 μs	1.6 μs	1.6 μs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 μs = $T_{DFT}/8$	0.4 μs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 μs=10× $T_{DFT}/4$	8 μs	8 μs	

<table>
<tr><th>Claim 14 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><td>$T_{HT\text{-}GF\text{-}STF}$: HT GF Short training sequence duration</td><td>N/A</td><td>8 μs=10× T_{DFT}/4</td><td>8 μs</td></tr>
<tr><td>$T_{L\text{-}LTF}$: Non-HT Long training sequence duration</td><td>8 μs=2× T_{DFT}+T_{GI2}</td><td>8 μs</td><td>8 μs</td></tr>
<tr><td>T_{SYM}: Symbol Interval</td><td>4 μs= T_{DFT}+T_{GI}</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td>T_{SYMS}: Short GI Symbol Interval</td><td>N/A</td><td>3.6 μs = T_{DFT}+T_{GIS}</td><td>3.6 μs
See NOTE 2</td></tr>
<tr><td>$T_{L\text{-}SIG}$</td><td>4 μs= T_{SYM}</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td>$T_{HT\text{-}SIG}$</td><td></td><td>8 μs= 2T_{SYM}</td><td>8 μs</td></tr>
<tr><td>$T_{HT\text{-}STF}$: HT-STF duration</td><td>N/A</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td>$T_{HT\text{-}LTF1}$: HT first long training field duration</td><td>N/A</td><td>4 μs in HT mixed format, 8 μs in greenfield format</td><td>4 μs in HT mixed format, 8 μs in greenfield format</td></tr>
<tr><td>$T_{HT\text{-}LTFs}$: HT second, and subsequent, long training fields duration</td><td>N/A</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td colspan="4">NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n58
</td></tr>
</table>

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.
[14.6] down-converting the amplified received up-converted analog signal using a second down-converter and a signal corresponding to the second RF center frequency to produce a fifth analog signal	802.11n D2.0 discloses “down-converting the amplified received up-converted analog signal using a second down-converter and a signal corresponding to the second RF center frequency to produce a fifth analog signal corresponding to the second analog signal.” See, e.g.: **high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
corresponding to the second analog signal.	**non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

Claim 14 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**

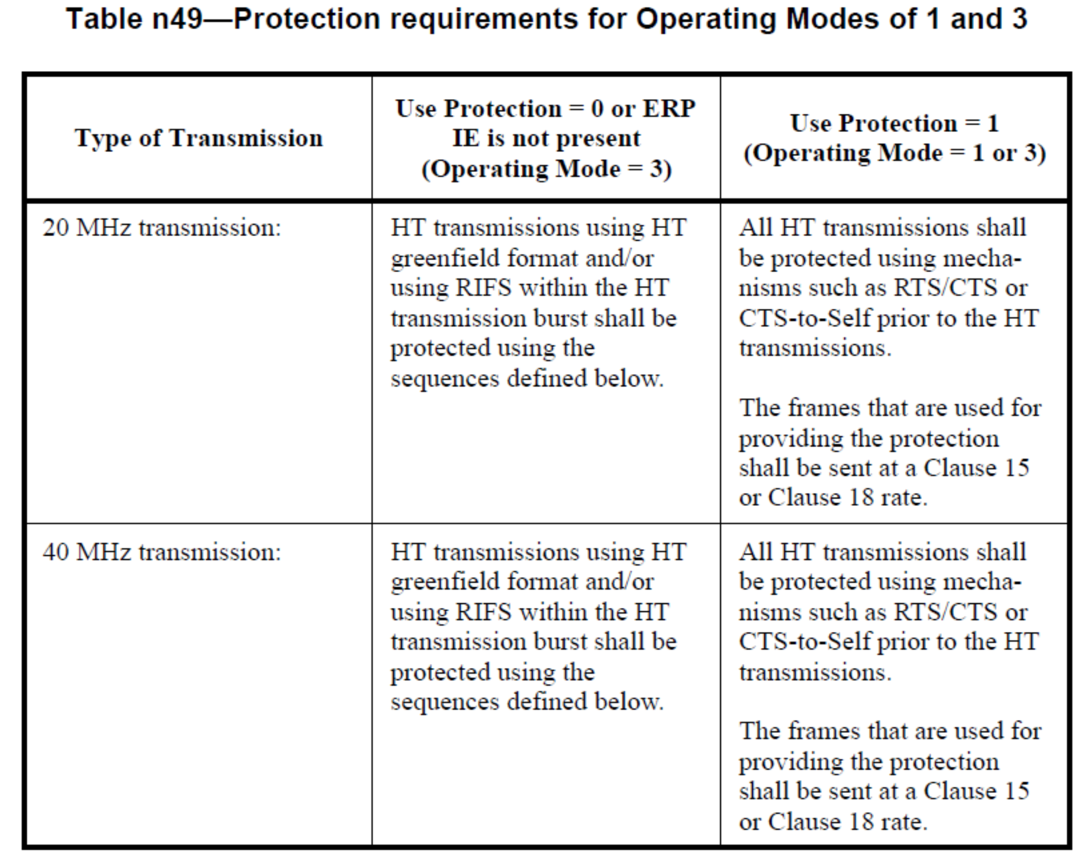


Table n49—Protection requirements for Operating Modes of 1 and 3

Type of Transmission	**Use Protection = 0 or ERP IE is not present (Operating Mode = 3)**	**Use Protection = 1 (Operating Mode = 1 or 3)**
20 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.
40 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.
NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).

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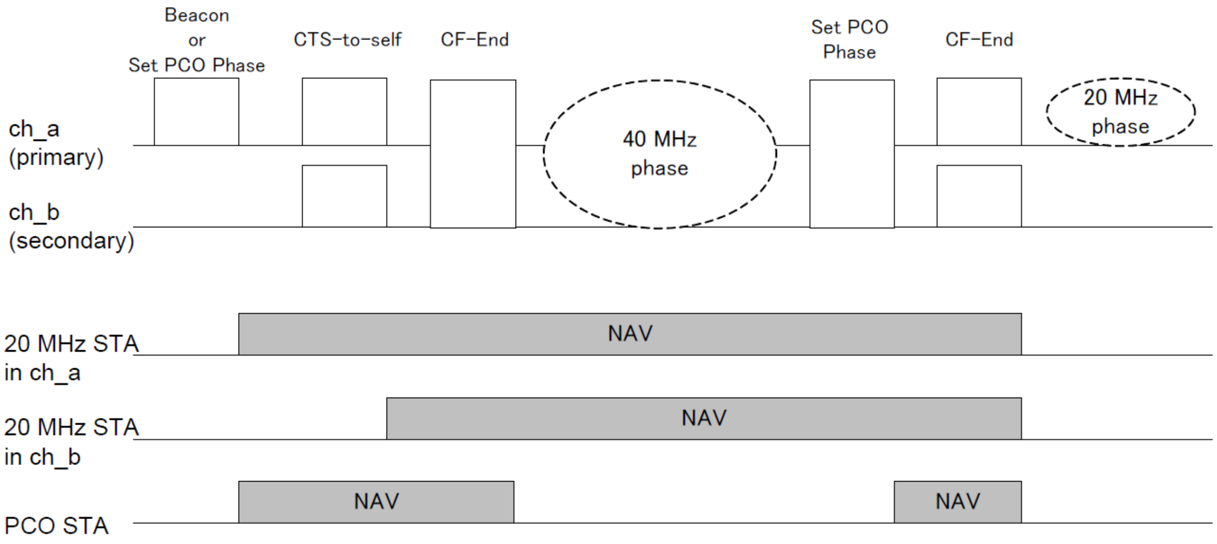
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

<table>
<tr><th>Claim 14 of the '802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>


A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU.

During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel.

During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS.

A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS.

The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.
</td></tr>
</table>

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	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

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	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

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	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

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	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

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	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $$r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t \right) \right\} \quad (20\text{-}1)$$ where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

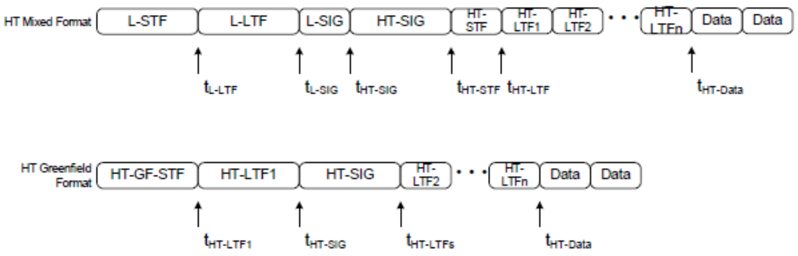

Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = \; & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right) T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \qquad (20\text{-}2)$$

where

$$t_{L-LTF} = T_{L-STF}$$

$$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$$

$$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$$

$$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r^{(i_{TX})}_{PPDU}(t) = {} & r^{(i_{TX})}_{HT-GF-STF}(t) + r^{(i_{TX})}_{HT-LTF1}(t - t_{HT-LTF1}) \\ & + r^{(i_{TX})}_{HT-SIG}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r^{(i_{TX}, i_{LTF})}_{HT-LTF}(t - t_{HT-LTFs} - (i_{LTF} - 2)T_{HT-LTFs}) \\ & + r^{(i_{TX})}_{HT-DATA}(t - t_{HT-DATA}) \end{aligned} \qquad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r^{(i_{TX})}_{\text{Field}}(t)$, is defined via the discrete Fourier transform as

$$r^{(i_{TX})}_{\text{Field}}(t) = \frac{1}{\sqrt{N^{\text{Tone}}_{\text{Field}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j2\pi k \Delta_F t) \qquad (20\text{-}4)$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \qquad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \qquad (20\text{-}6)$$

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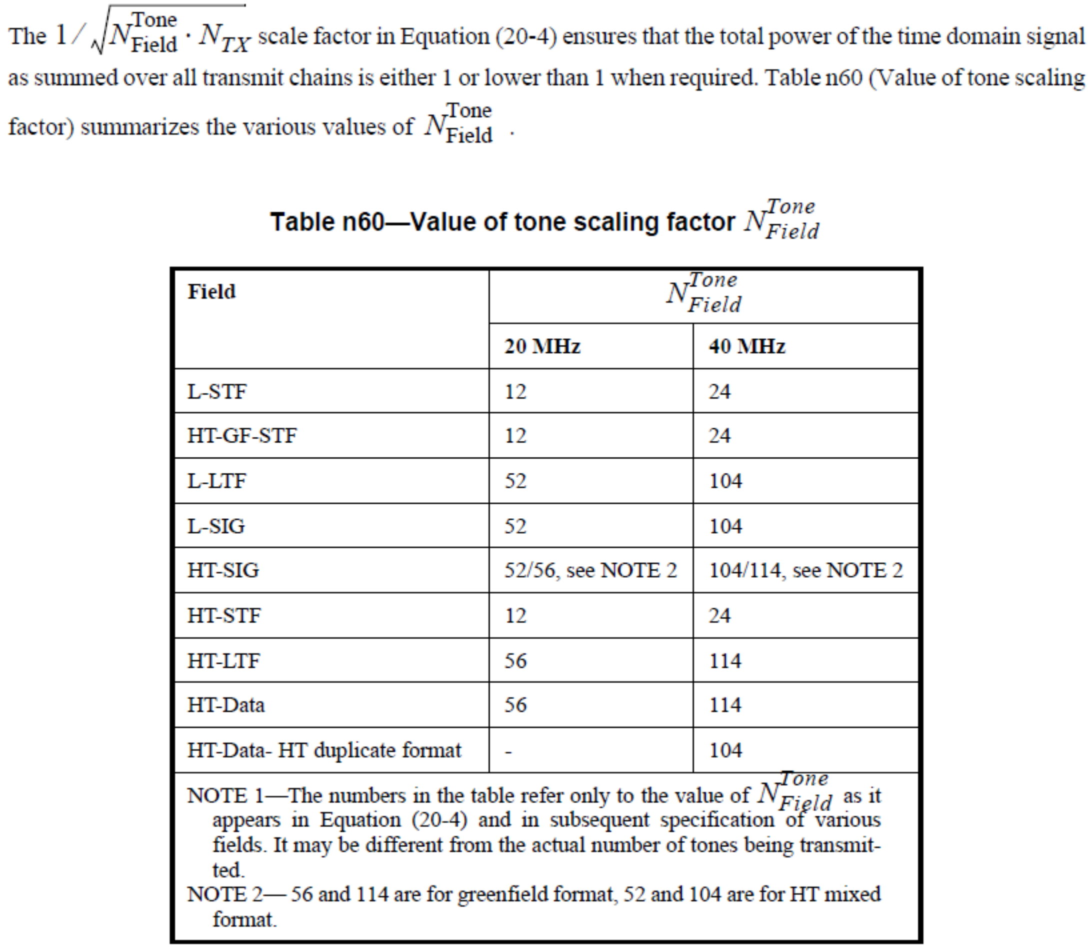

The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	**40 MHz**
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

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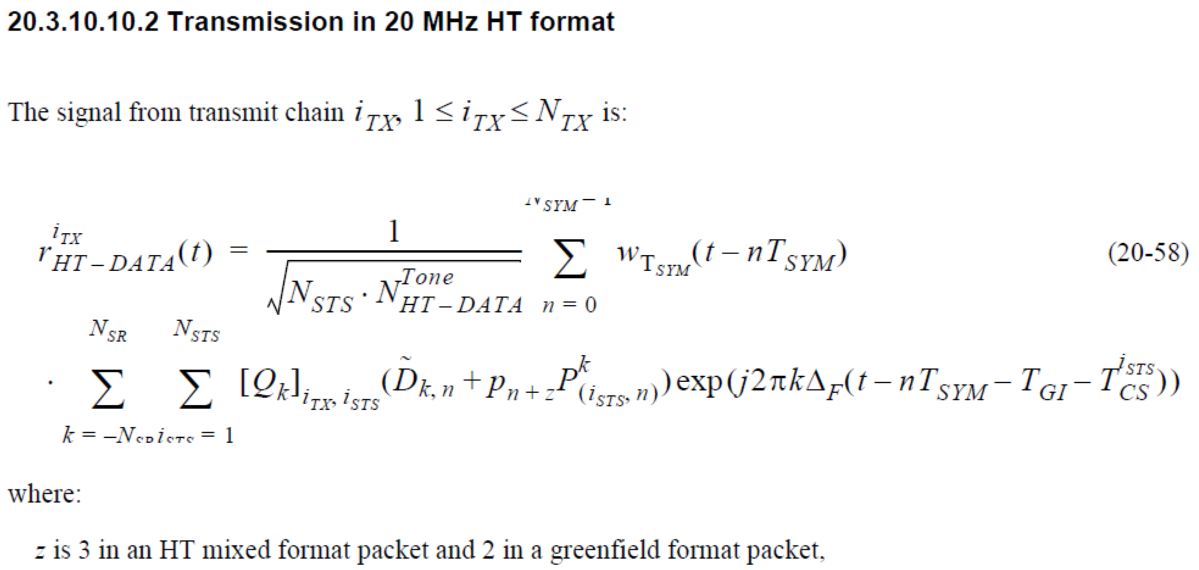
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS} \cdot N^{Tone}_{HT-DATA}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX},i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P^k_{(i_{STS},n)}) \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T^{i_{STS}}_{CS}))$ (20-58) where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

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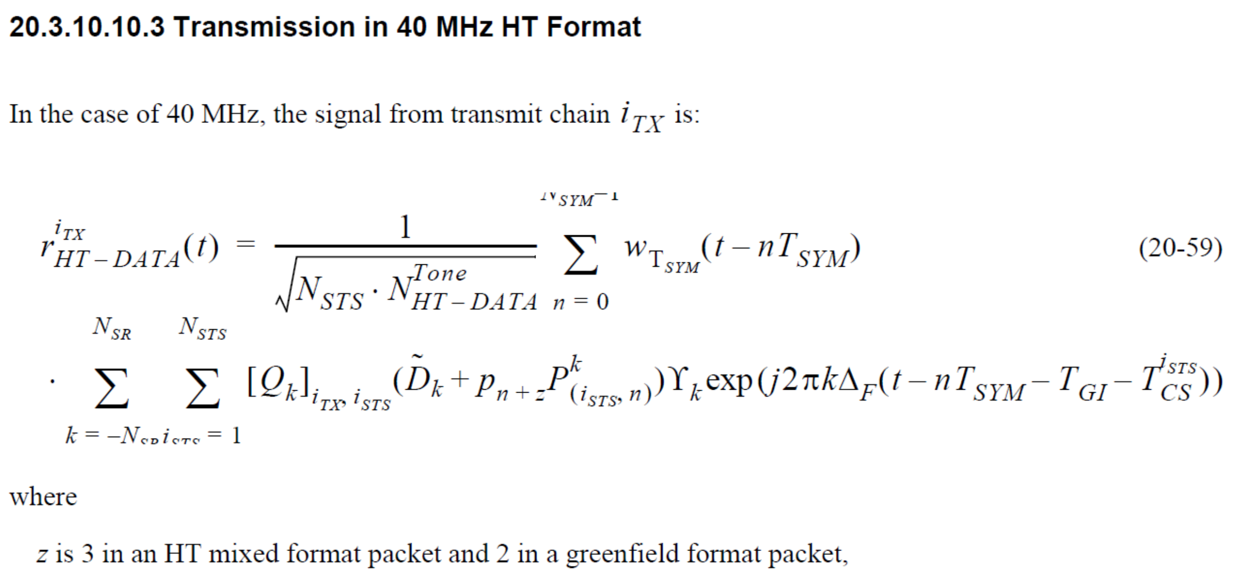
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $$r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P_{(i_{STS}, n)}^{k}) \Upsilon_k \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}})) \quad (20\text{-}59)$$ where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

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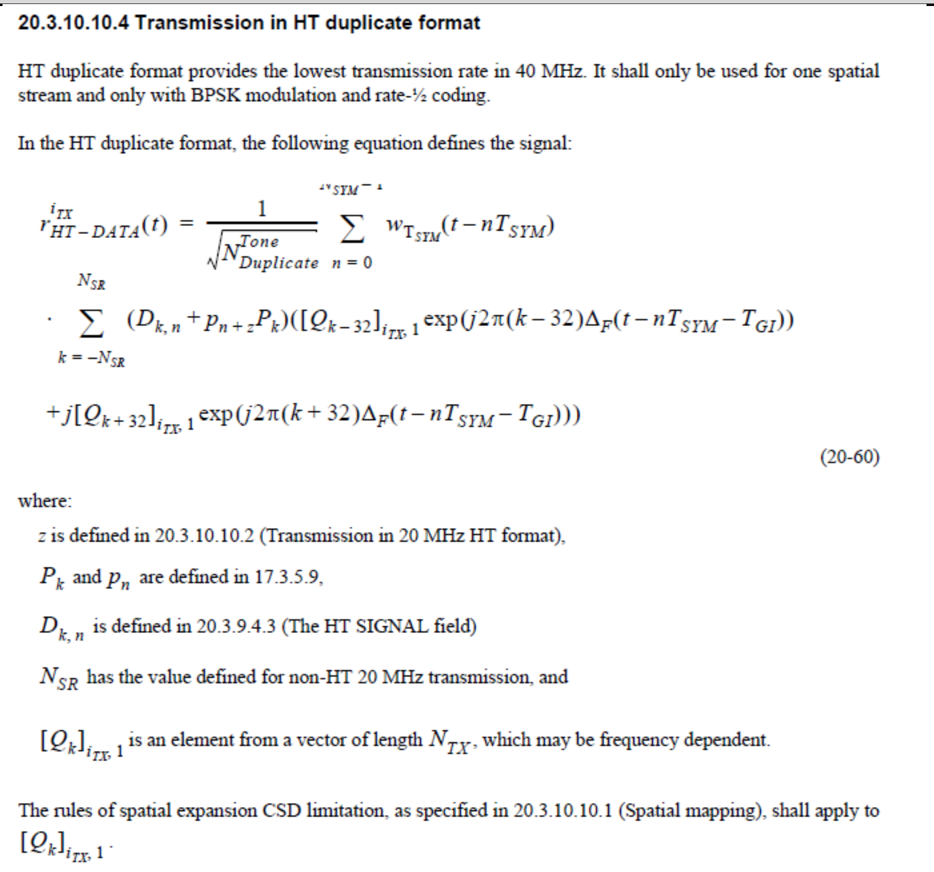
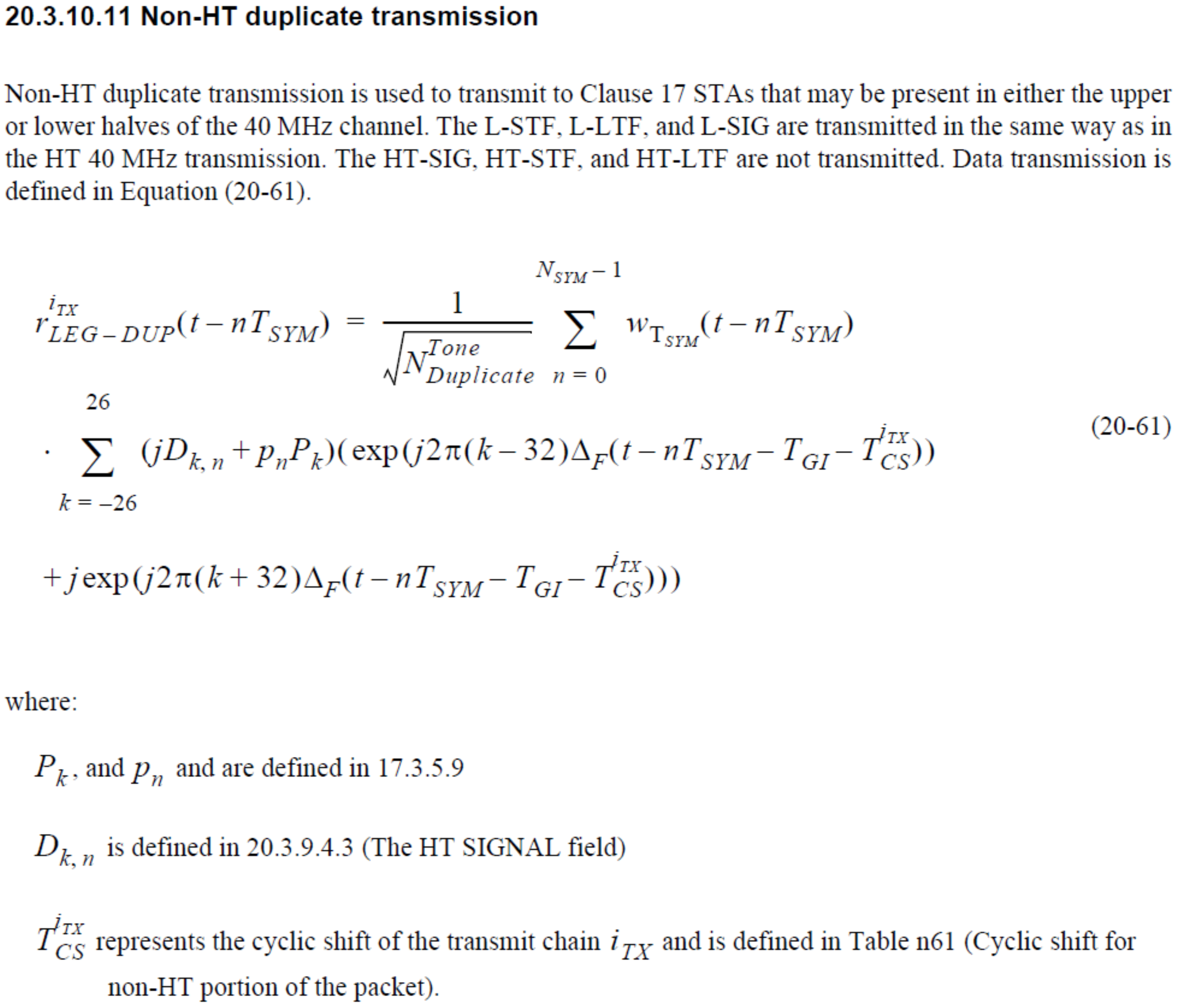
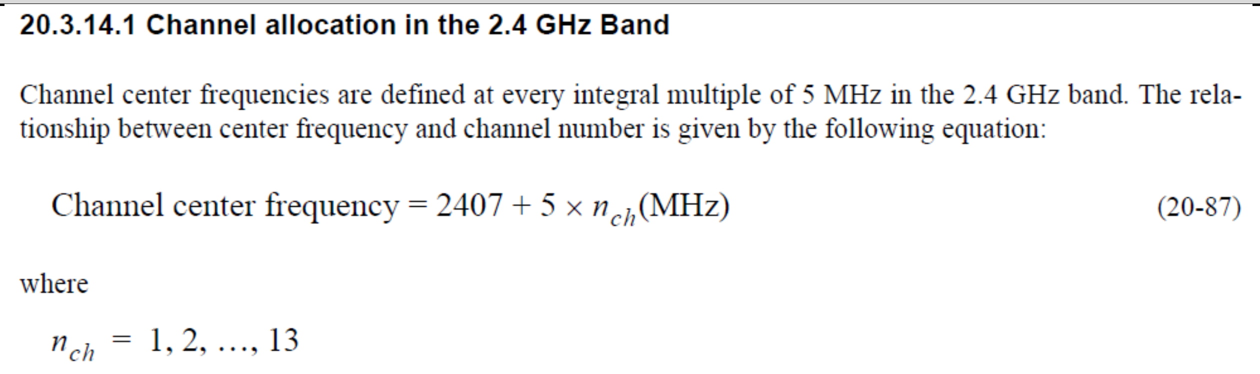
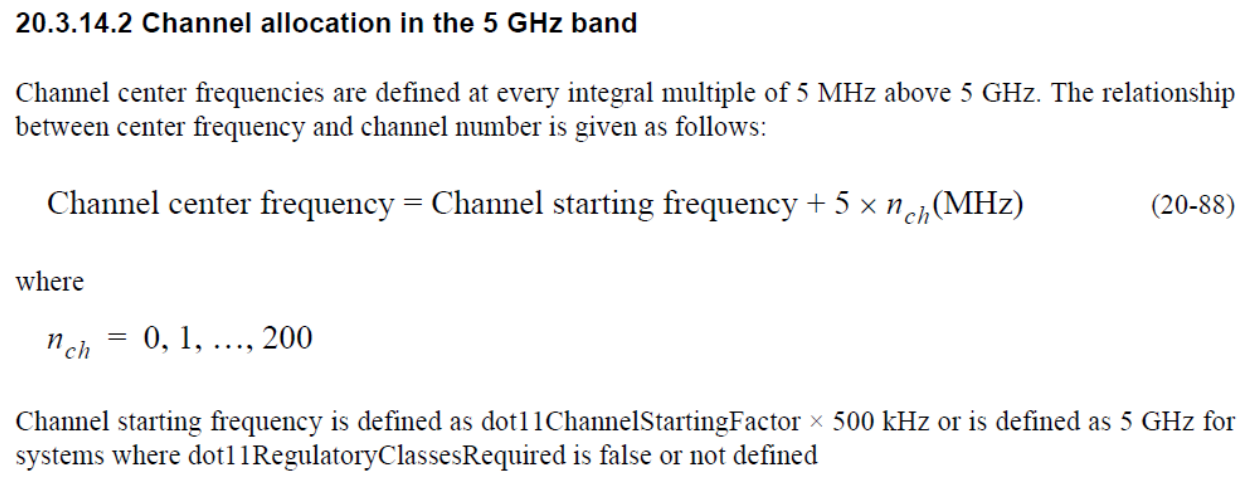
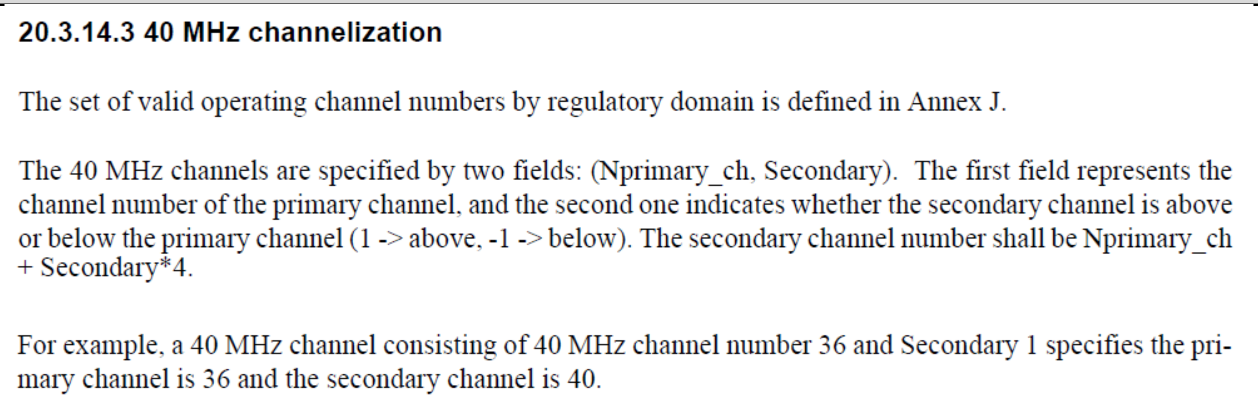
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $$r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n}+p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1}\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI})) + j[Q_{k+32}]_{i_{TX},1}\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}))) \quad (20\text{-}60)$$ where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $$r^{i_{TX}}_{LEG-DUP}(t-nT_{SYM}) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}}\sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26}(jD_{k,n}+p_nP_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})))\qquad(20\text{-}61)$$ where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T^{i_{TX}}_{CS}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz})$ (20-87) where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz})$ (20-88) where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

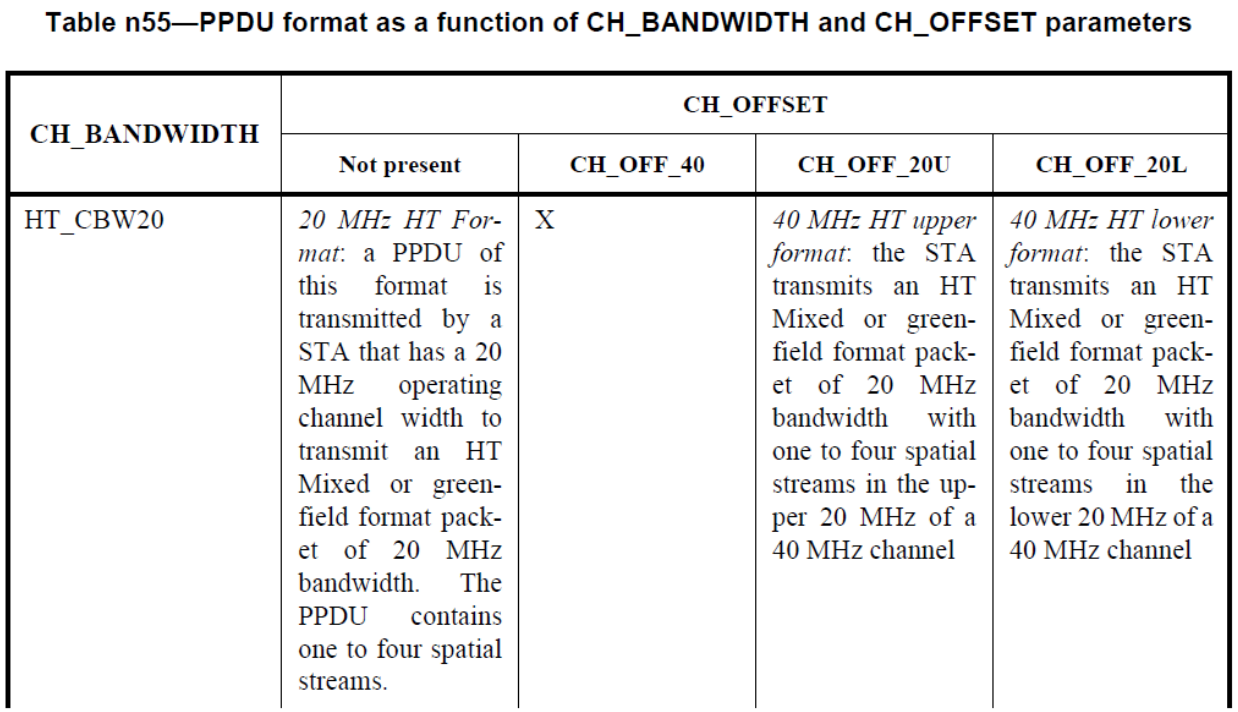
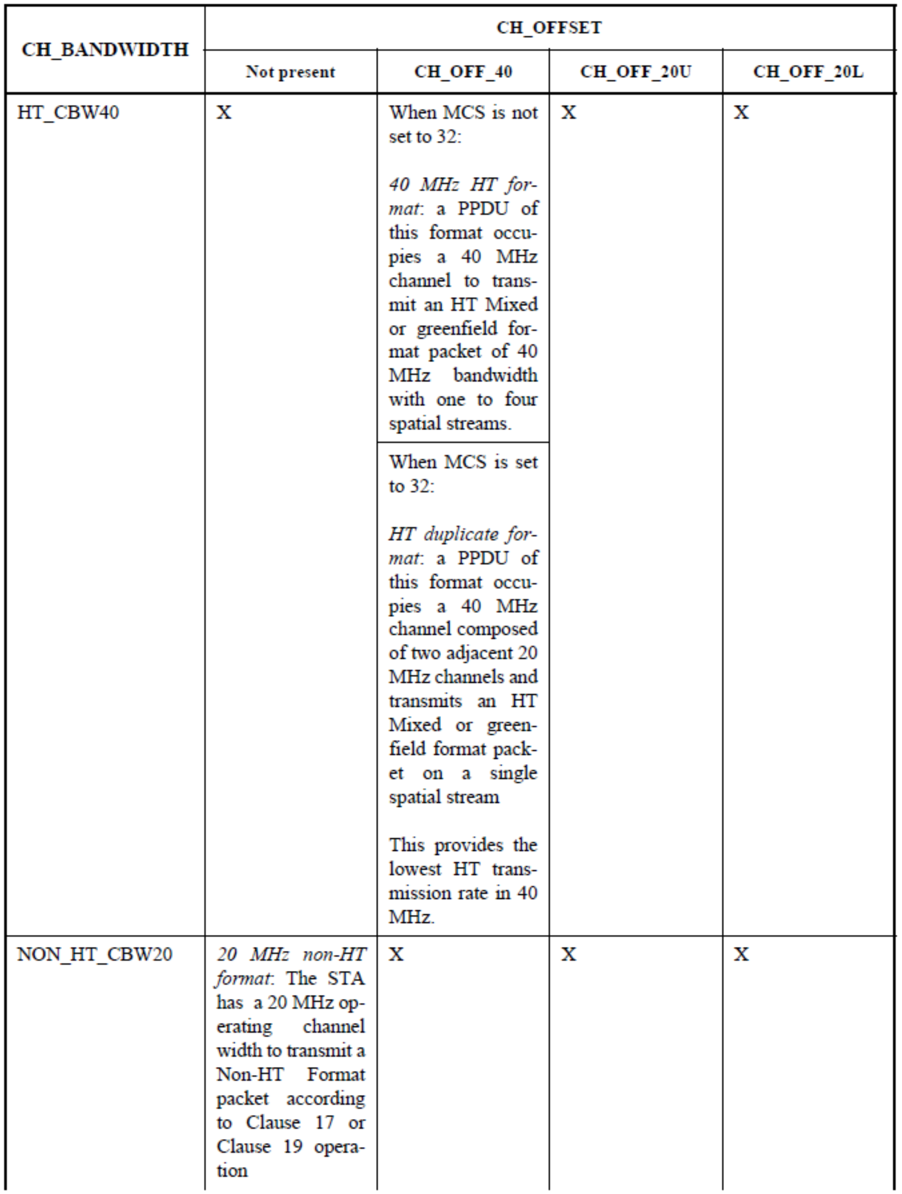
Claim 14 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.20.3 

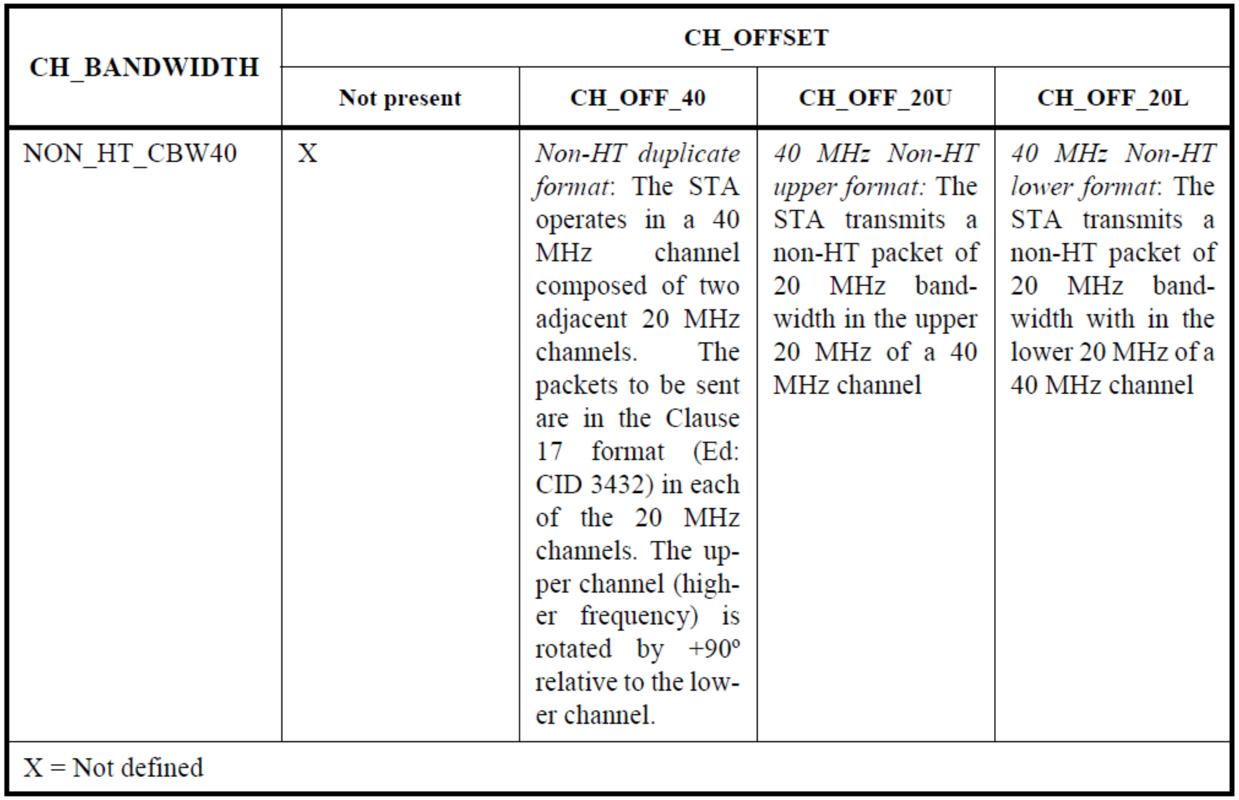
Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

CH_BANDWIDTH	**CH_OFFSET**			
	Not present	**CH_OFF_40**	**CH_OFF_20U**	**CH_OFF_20L**
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel



CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams.	X	X
		When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.		
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0



CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
NON_HT_CBW40	X	*Non-HT duplicate format*: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.	*40 MHz Non-HT upper format:* The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel	*40 MHz Non-HT lower format*: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel
X = Not defined				

See, e.g., 802.11n D2.0 Table n55

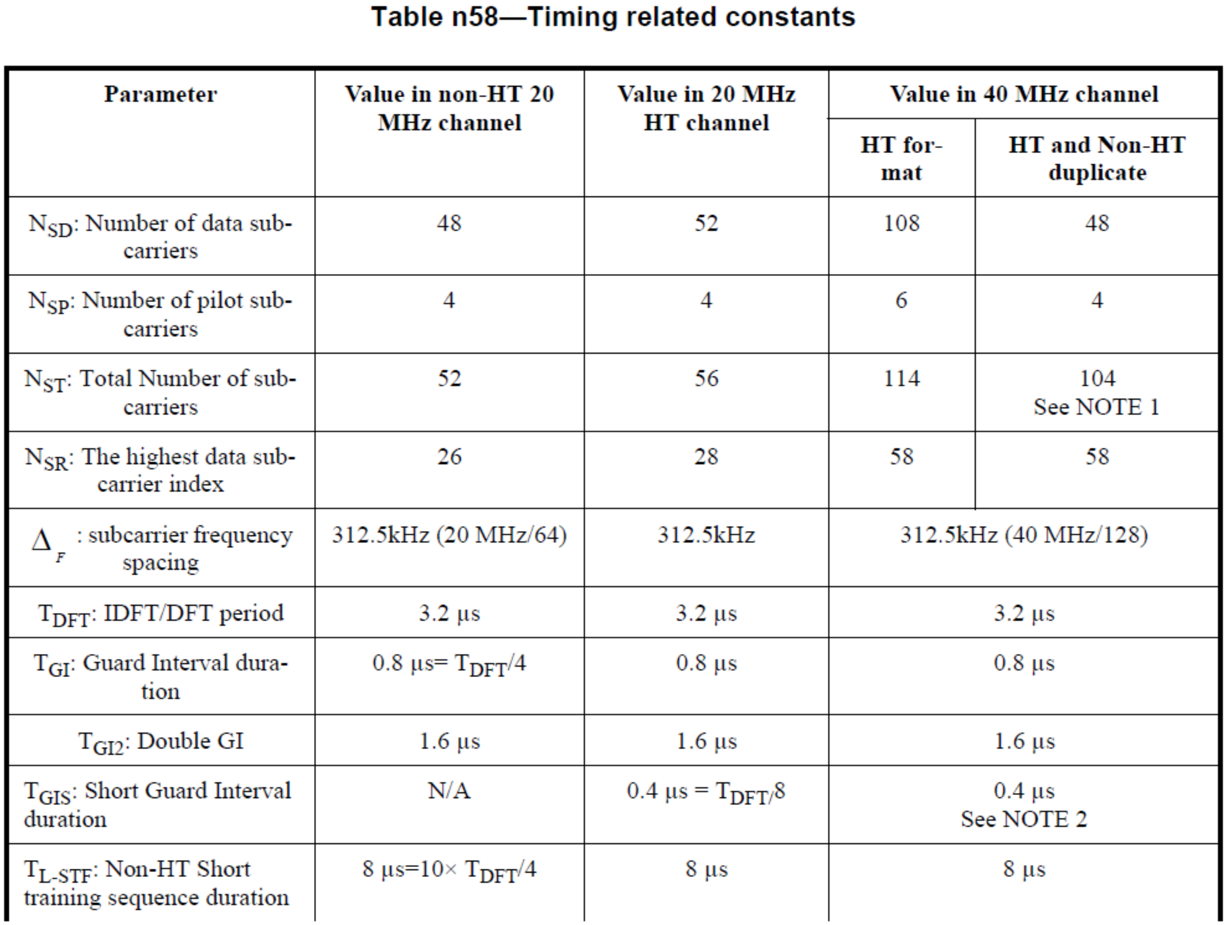
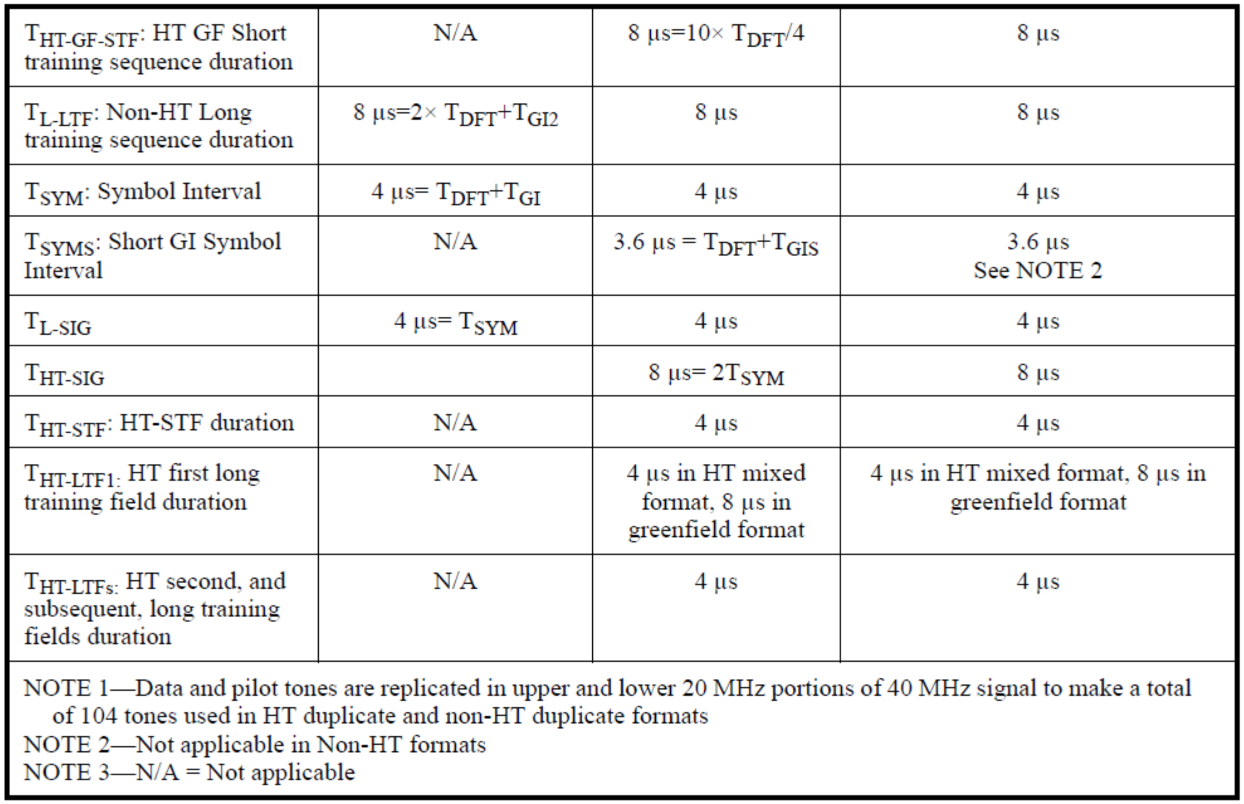
Claim 14 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	

Table n58—Timing related constants

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

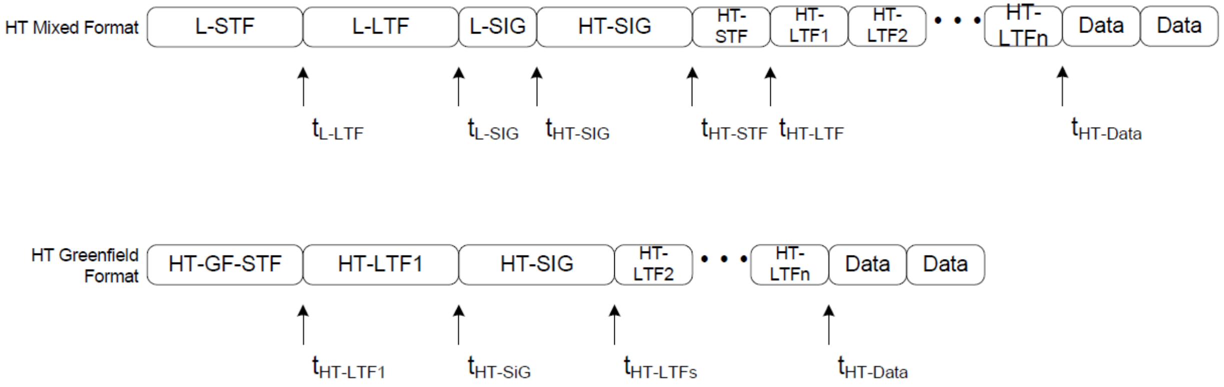
Claim 14 of the '802 Patent	**Prior Art Reference – 802.11n D2.0**



$T_{HT\text{-}GF\text{-}STF}$: HT GF Short training sequence duration	N/A	8 µs=10× T_{DFT}/4	8 µs
$T_{L\text{-}LTF}$: Non-HT Long training sequence duration	8 µs=2× $T_{DFT}+T_{GI2}$	8 µs	8 µs
T_{SYM}: Symbol Interval	4 µs= $T_{DFT}+T_{GI}$	4 µs	4 µs
T_{SYMS}: Short GI Symbol Interval	N/A	3.6 µs = $T_{DFT}+T_{GIS}$	3.6 µs See NOTE 2
$T_{L\text{-}SIG}$	4 µs= T_{SYM}	4 µs	4 µs
$T_{HT\text{-}SIG}$		8 µs= $2T_{SYM}$	8 µs
$T_{HT\text{-}STF}$: HT-STF duration	N/A	4 µs	4 µs
$T_{HT\text{-}LTF1}$: HT first long training field duration	N/A	4 µs in HT mixed format, 8 µs in greenfield format	4 µs in HT mixed format, 8 µs in greenfield format
$T_{HT\text{-}LTFs}$: HT second, and subsequent, long training fields duration	N/A	4 µs	4 µs

NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable

See, e.g., 802.11n D2.0 Table n58

Claim 14 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.

Claim 17 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
[17.1] A wireless communication system comprising:	To the extent the preamble is limiting, 802.11n D2.0 discloses “A wireless communication system comprising.” See, e.g.: **20.1 Introduction**

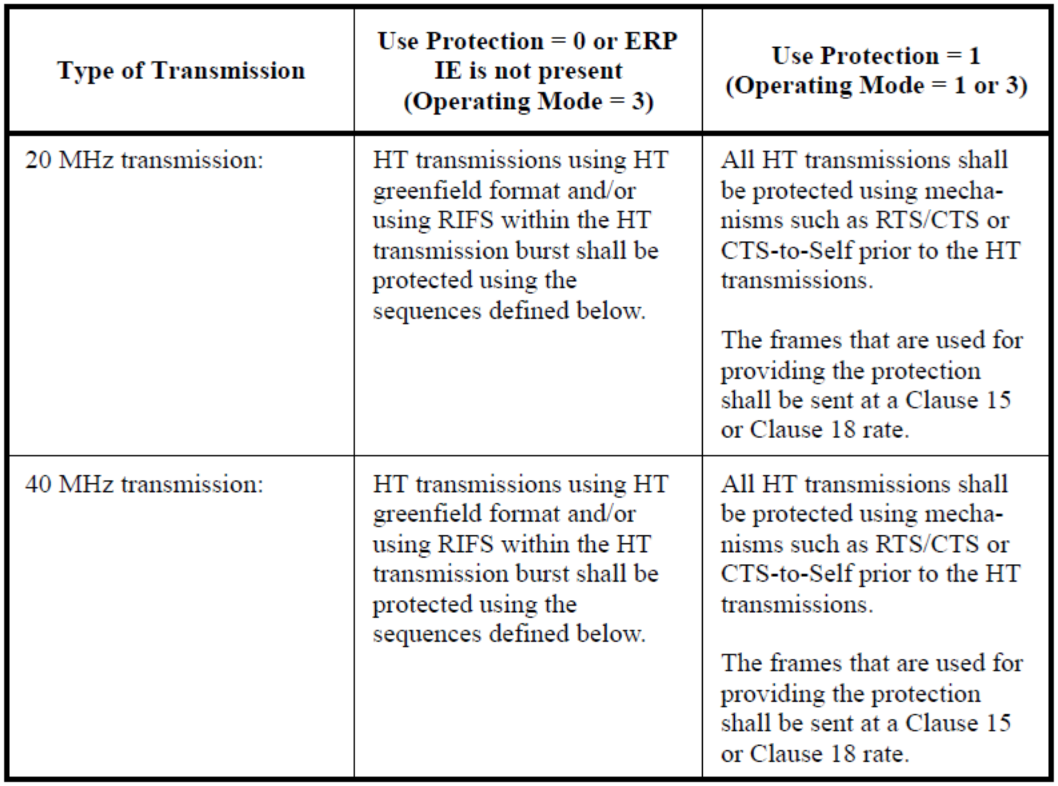
Claim 17 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission (as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes.

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.
[17.2] a baseband digital system for providing a first digital signal comprising a first data to be transmitted and a second digital signal comprising a second data to be transmitted;	802.11n D2.0 discloses “a baseband digital system for providing a first digital signal comprising a first data to be transmitted and a second digital signal comprising a second data to be transmitted.” See, e.g.: **high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19 **non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection

Claim 17 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

Claim 17 of the '802 Patent	Prior Art Reference – 802.11n D2.0

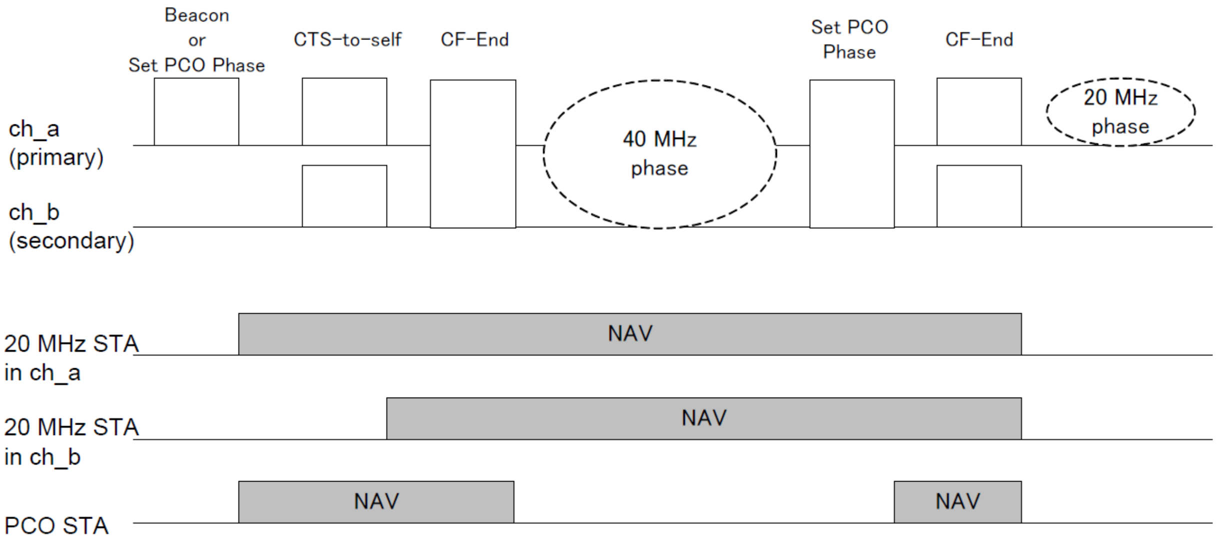
Table n49—Protection requirements for Operating Modes of 1 and 3



Type of Transmission	Use Protection = 0 or ERP IE is not present (Operating Mode = 3)	Use Protection = 1 (Operating Mode = 1 or 3)
20 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.
40 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.
NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

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	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

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	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t \right) \right\}$ (20-1) where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

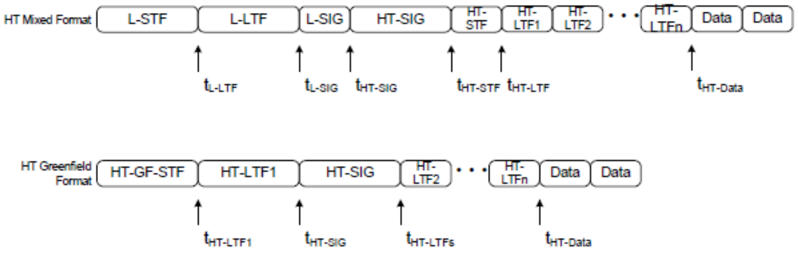

Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t-t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t-t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t-t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t-t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t-t_{HT-LTF}-\left(i_{LTF}-1\right)T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}(t-t_{HT-DATA}) \end{aligned} \quad (20\text{-}2)$$

where

$$t_{L-LTF} = T_{L-STF}$$

$$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$$

$$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$$

$$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1}) \\ & + r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2)T_{HT-LTFs}) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \tag{20-3}$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\text{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\text{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_k \Upsilon_k X_k^{(i_{TX})} \exp(j2\pi k \Delta_F t) \tag{20-4}$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \tag{20-5}$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \tag{20-6}$$

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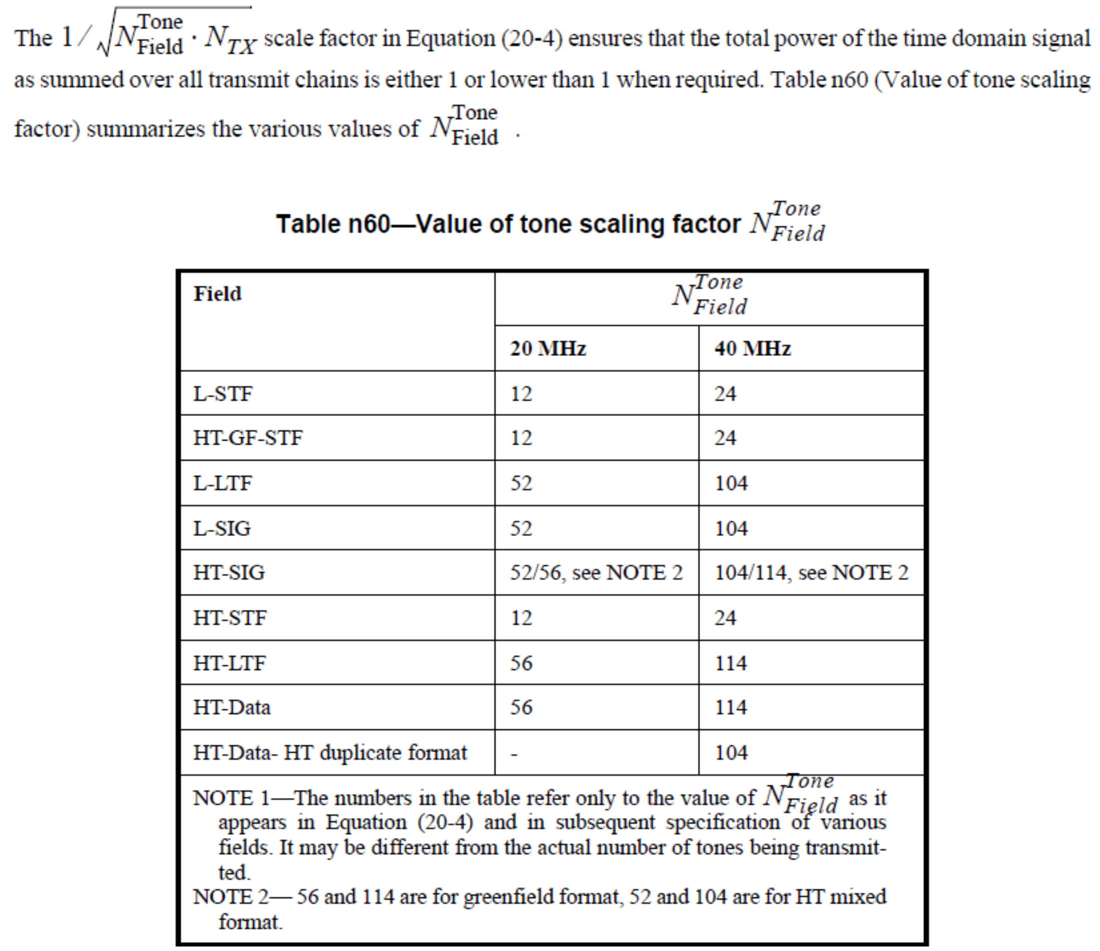

The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	**40 MHz**
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

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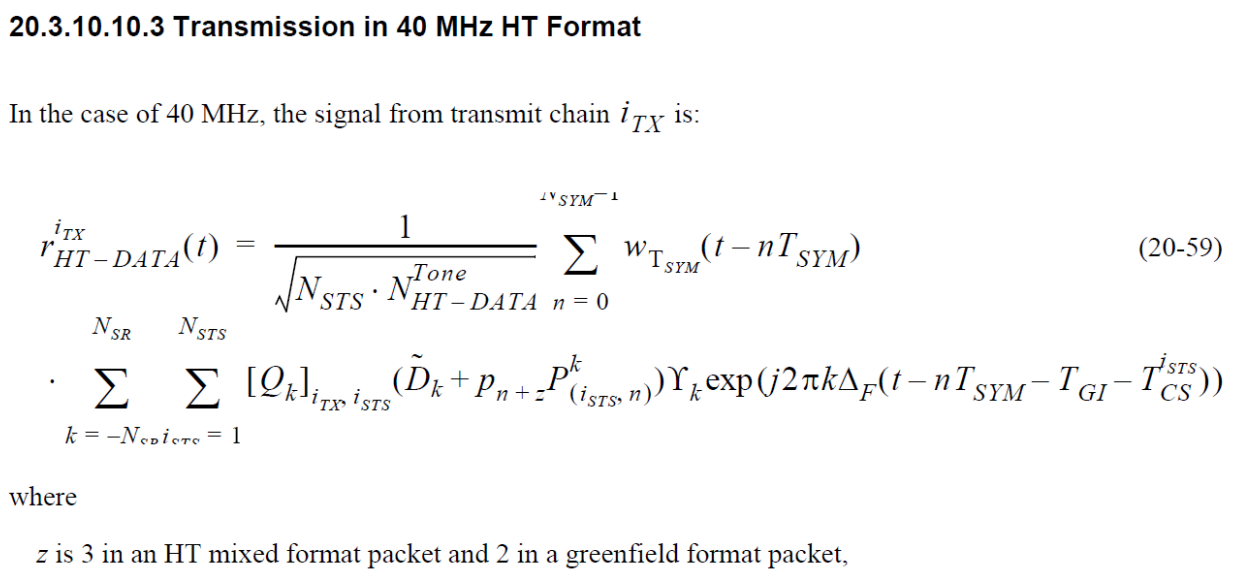
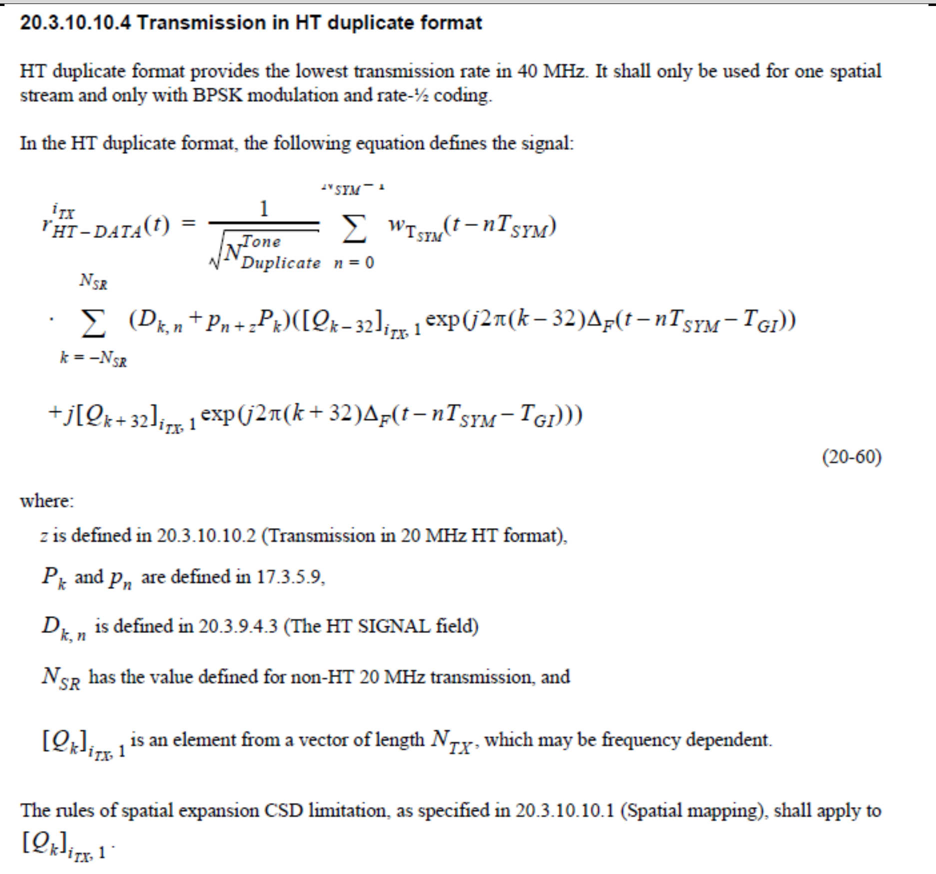
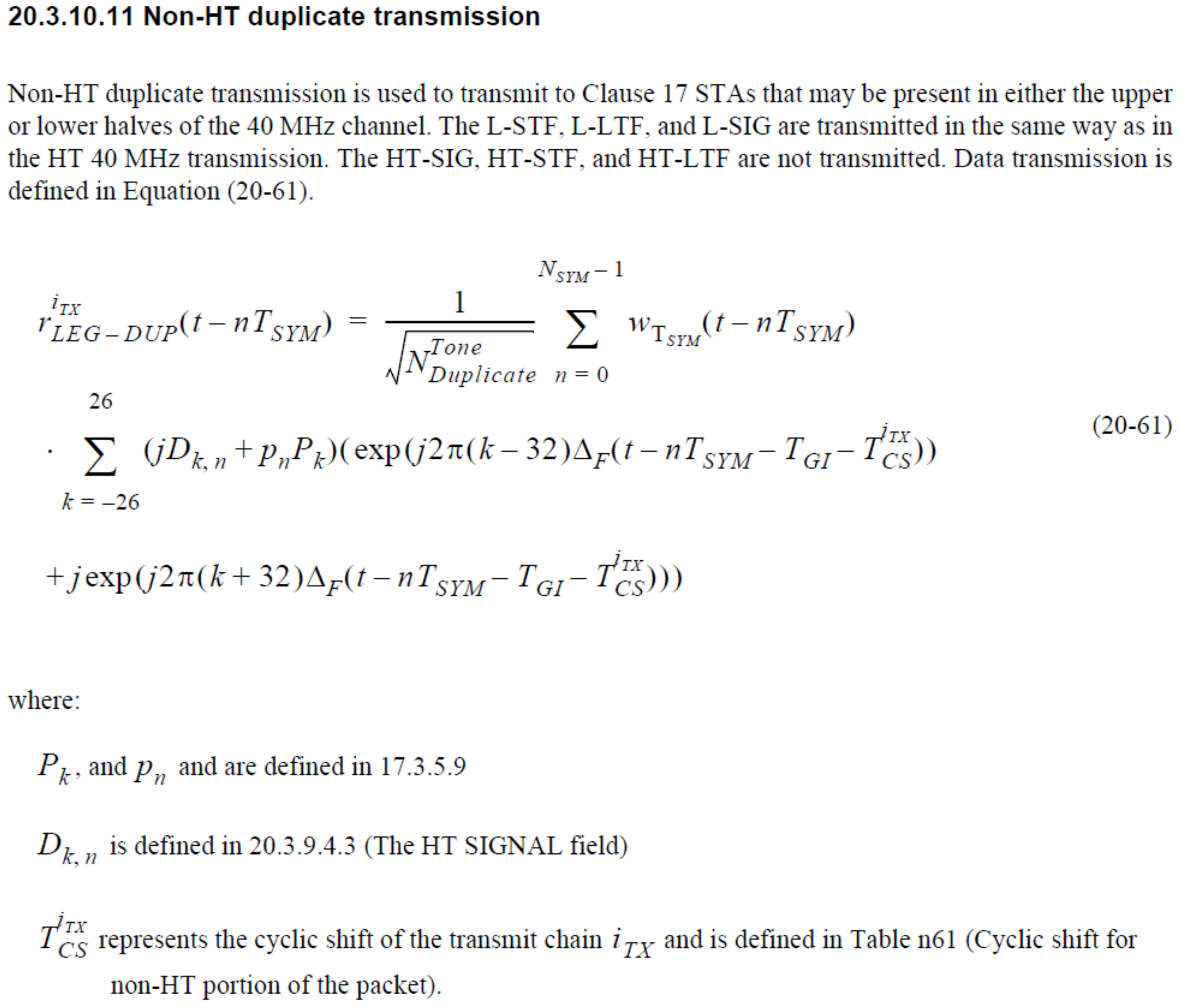
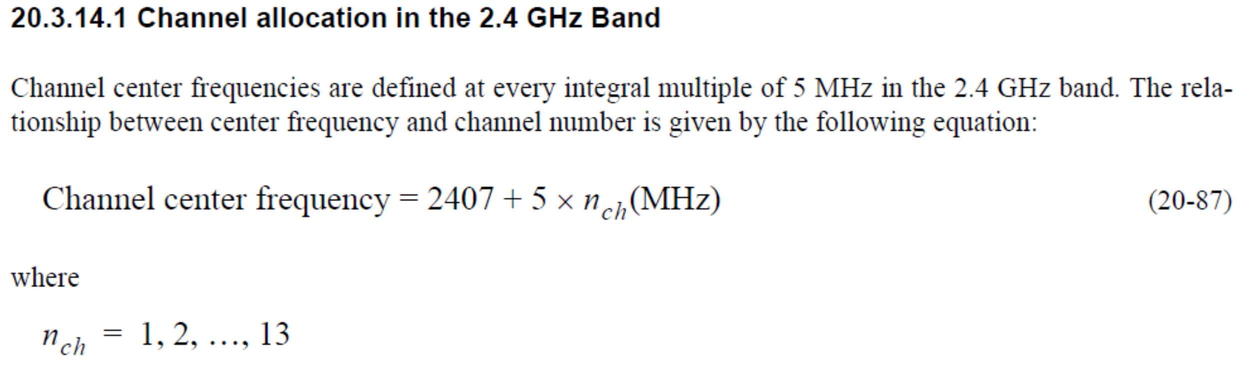
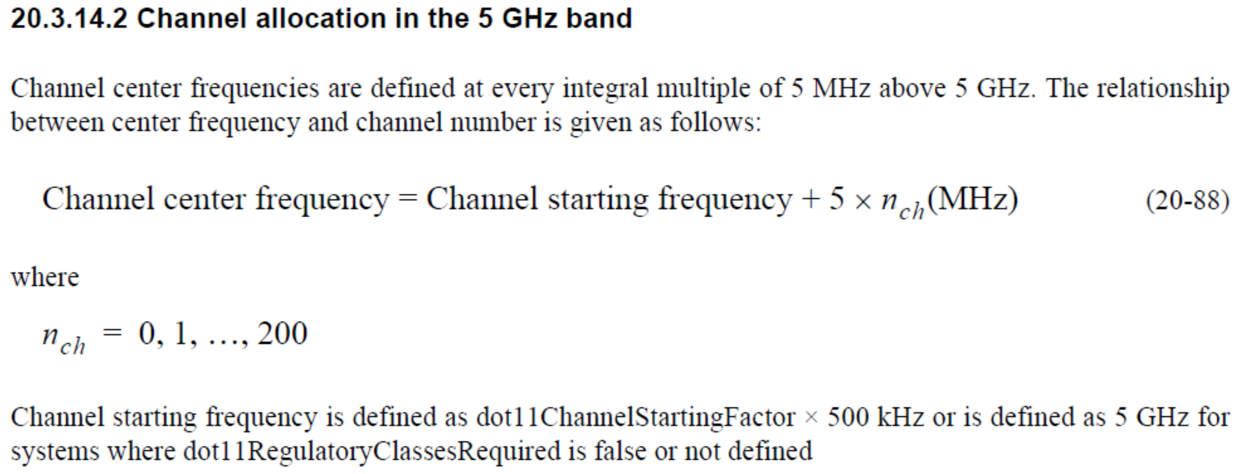
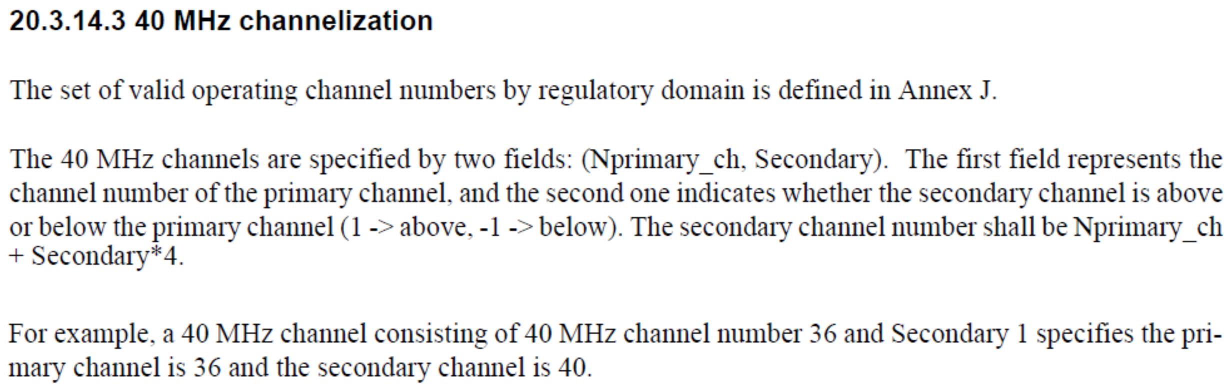
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P_{(i_{STS}, n)}^{k}) \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (20-58) where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

Claim 17 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS} \cdot N^{Tone}_{HT-DATA}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P^k_{(i_{STS}, n)}) \Upsilon_k \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T^{i_{STS}}_{CS}))$ (20-59) where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM})$ $\cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n}+p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}))$ $+j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r_{LEG-DUP}^{i_{TX}}(t-nT_{SYM}) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n}+p_nP_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{TX}})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{TX}})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T_{CS}^{i_{TX}}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz})$ (20-87) where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz})$ (20-88) where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

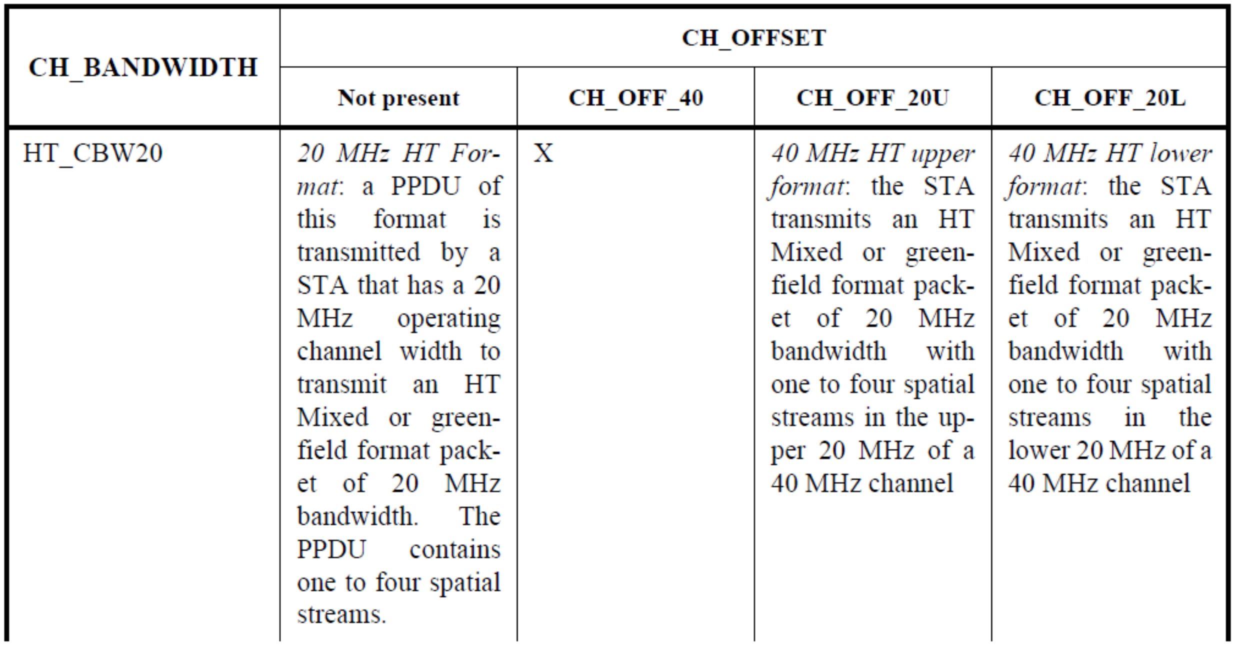
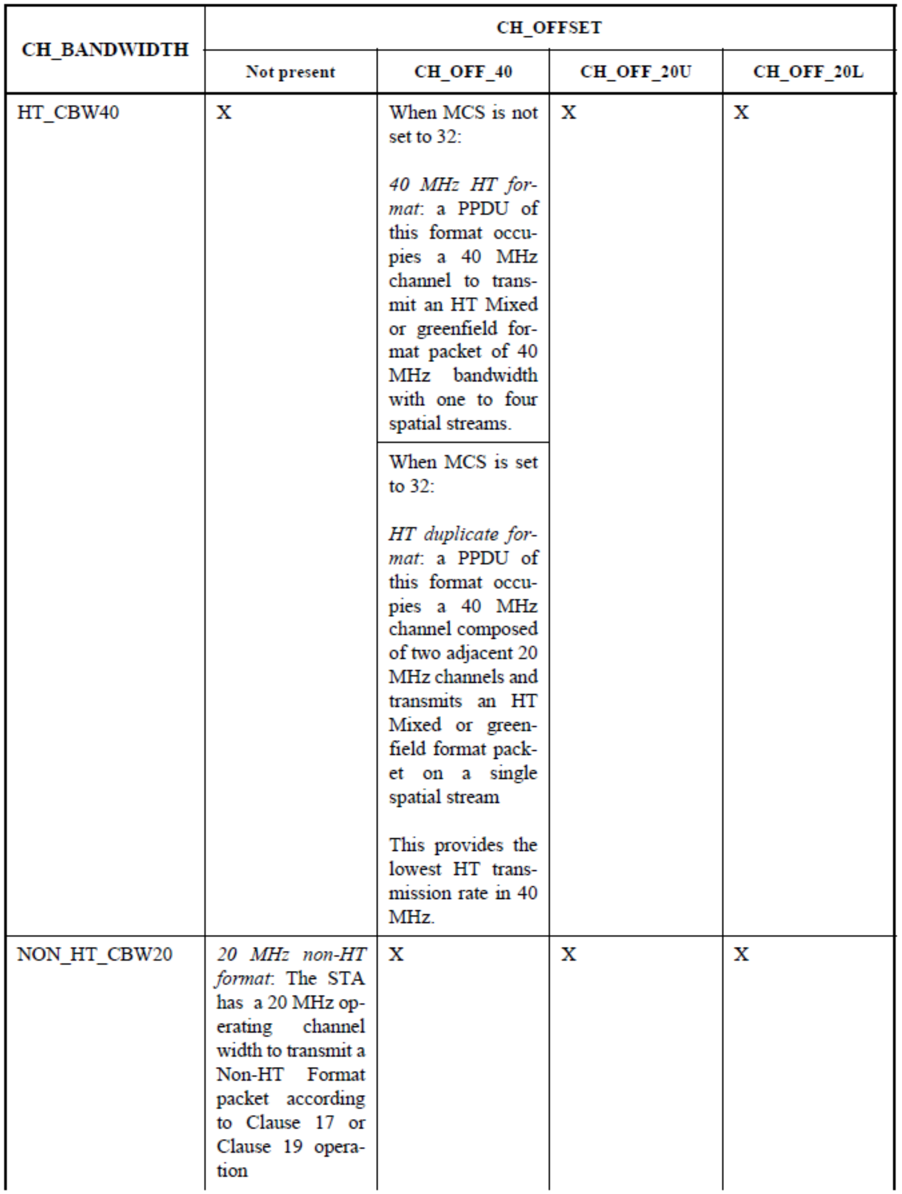
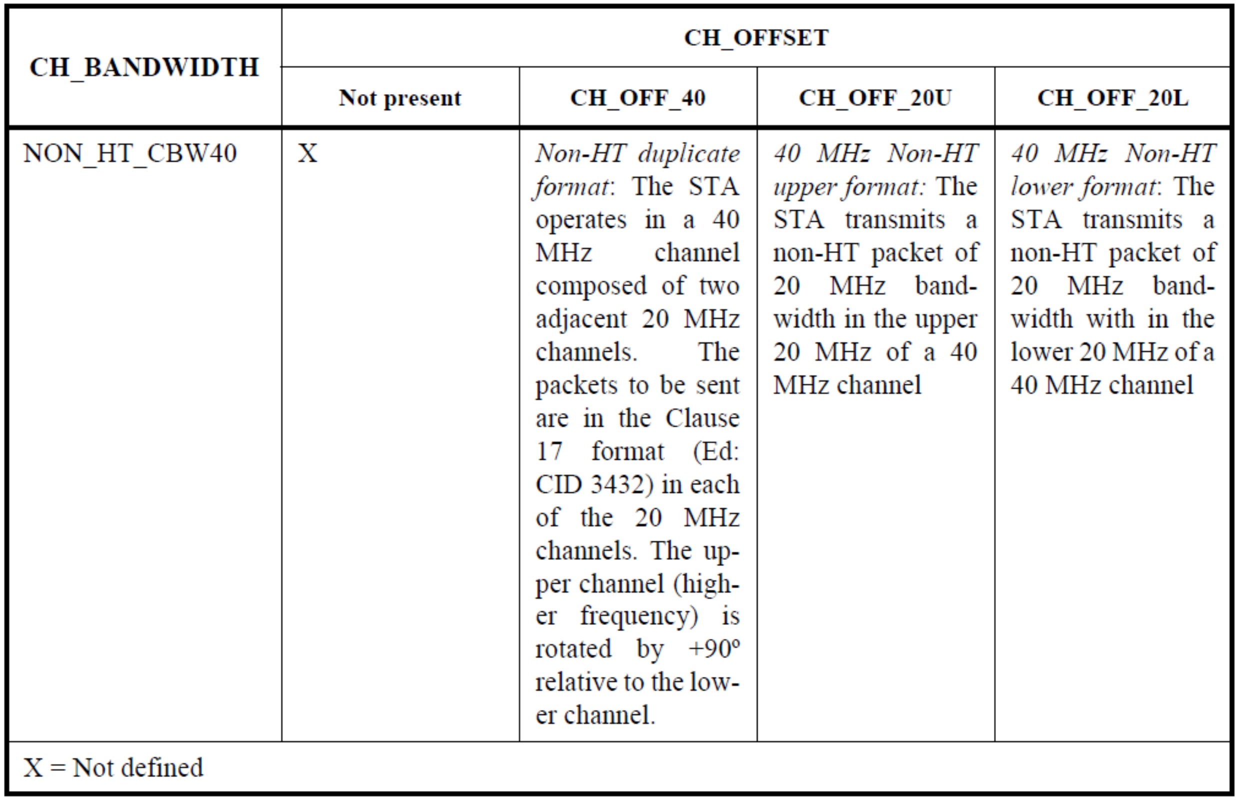
Claim 17 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.20.3 Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters 

Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel



CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

<table>
<tr><th>Claim 17 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>NON_HT_CBW40</td><td>X</td><td>*Non-HT duplicate format*: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.</td><td>*40 MHz Non-HT upper format:* The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel</td><td>*40 MHz Non-HT lower format*: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel</td></tr>
<tr><td colspan="5">X = Not defined</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n55
</td></tr>
</table>

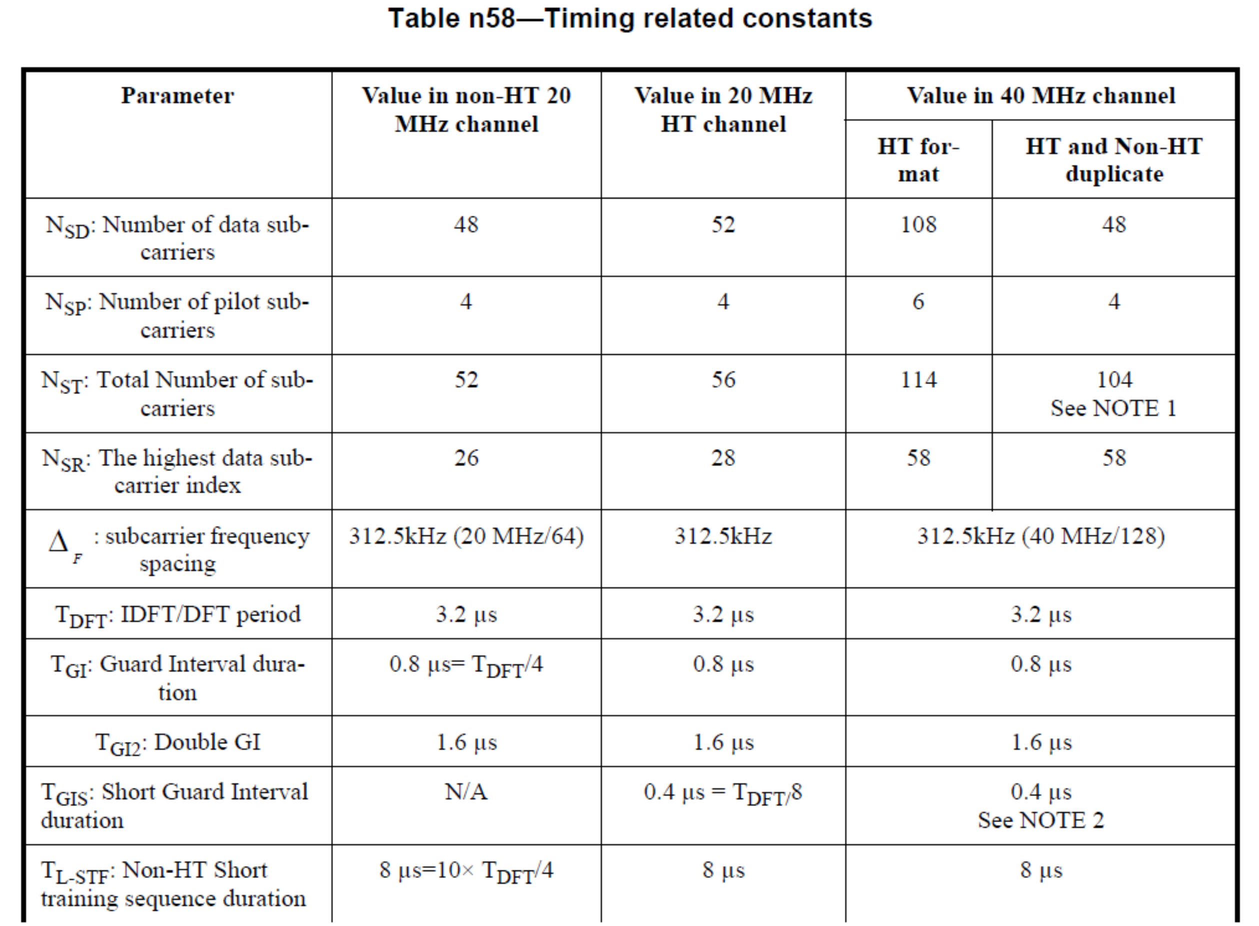
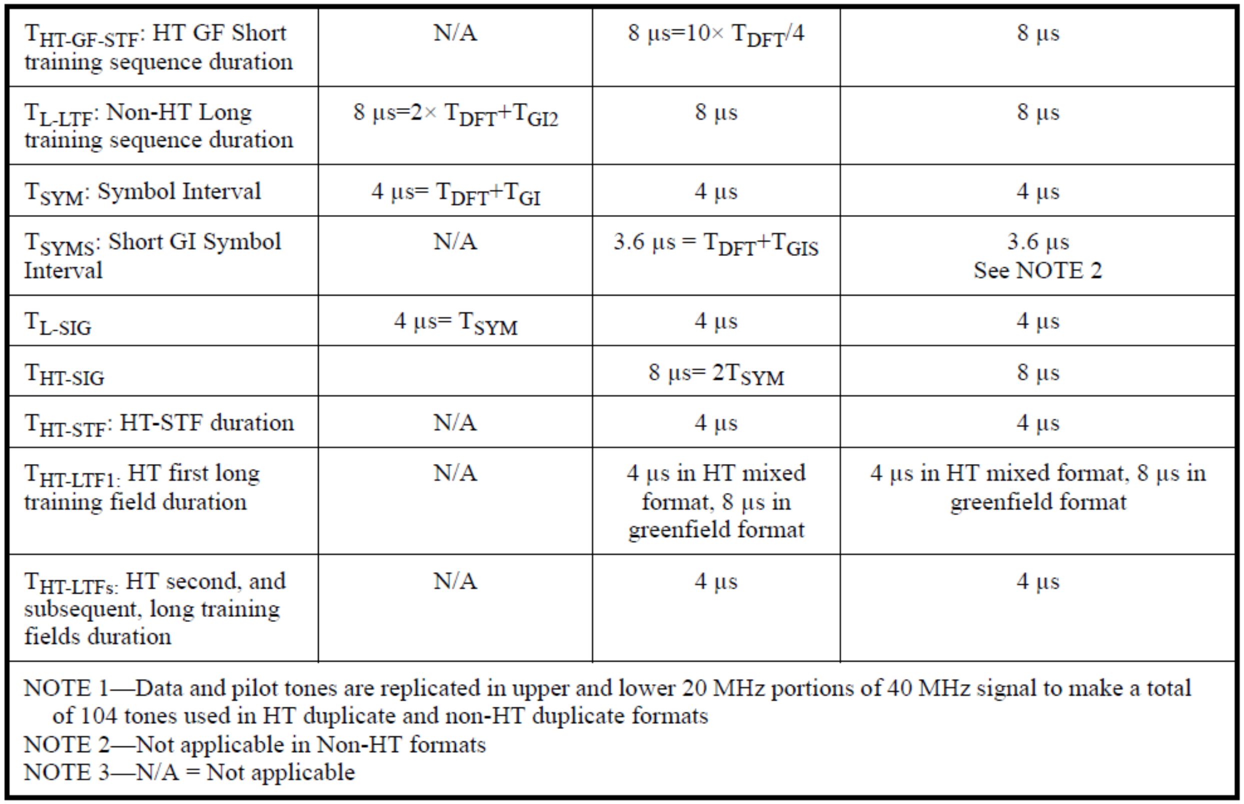
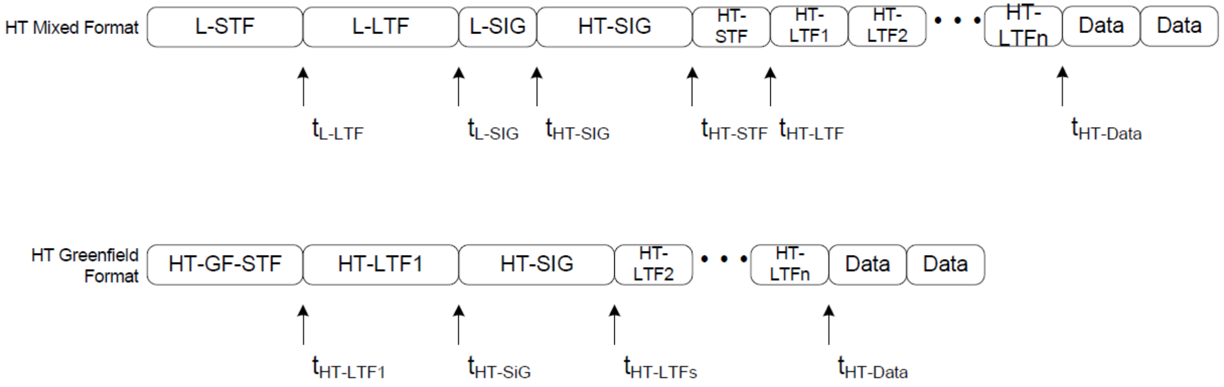
Claim 17 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	

Table n58—Timing related constants

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
T_{L-STF}: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

<table>
<tr><th>Claim 17 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><td>$T_{HT\text{-}GF\text{-}STF}$: HT GF Short training sequence duration</td><td>N/A</td><td>8 μs=10× T_{DFT}/4</td><td>8 μs</td></tr>
<tr><td>$T_{L\text{-}LTF}$: Non-HT Long training sequence duration</td><td>8 μs=2× T_{DFT}+T_{GI2}</td><td>8 μs</td><td>8 μs</td></tr>
<tr><td>T_{SYM}: Symbol Interval</td><td>4 μs= T_{DFT}+T_{GI}</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td>T_{SYMS}: Short GI Symbol Interval</td><td>N/A</td><td>3.6 μs = T_{DFT}+T_{GIS}</td><td>3.6 μs
See NOTE 2</td></tr>
<tr><td>$T_{L\text{-}SIG}$</td><td>4 μs= T_{SYM}</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td>$T_{HT\text{-}SIG}$</td><td></td><td>8 μs= 2T_{SYM}</td><td>8 μs</td></tr>
<tr><td>$T_{HT\text{-}STF}$: HT-STF duration</td><td>N/A</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td>$T_{HT\text{-}LTF1}$: HT first long training field duration</td><td>N/A</td><td>4 μs in HT mixed format, 8 μs in greenfield format</td><td>4 μs in HT mixed format, 8 μs in greenfield format</td></tr>
<tr><td>$T_{HT\text{-}LTFs}$: HT second, and subsequent, long training fields duration</td><td>N/A</td><td>4 μs</td><td>4 μs</td></tr>
<tr><td colspan="4">NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable</td></tr>
</table>

See, e.g., 802.11n D2.0 Table n58
</td></tr>
</table>

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.
[17.3] a first digital-to-analog converter for receiving the first digital signal and converting the first digital signal into a first analog signal, the first analog signal	802.11n D2.0 discloses “a first digital-to-analog converter for receiving the first digital signal and converting the first digital signal into a first analog signal, the first analog signal carrying the first data across a first frequency range.” See, e.g.: **high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
carrying the first data across a first frequency range;	**non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

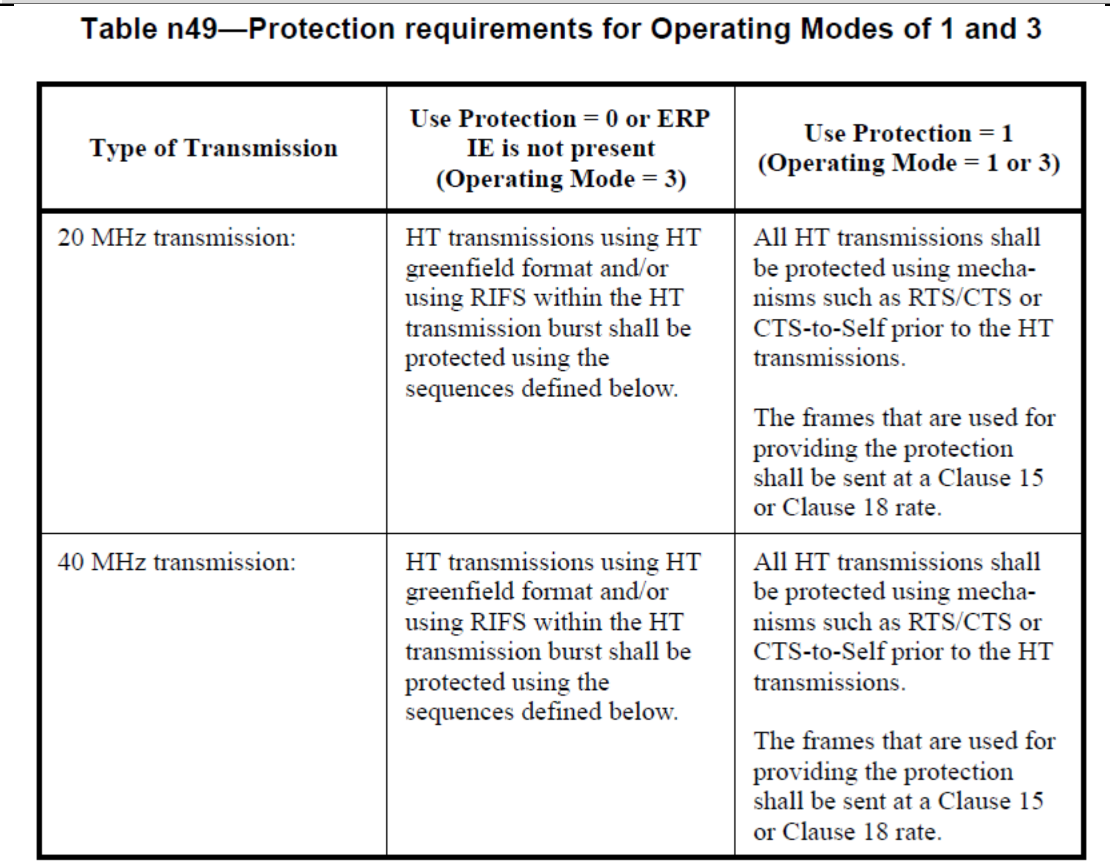
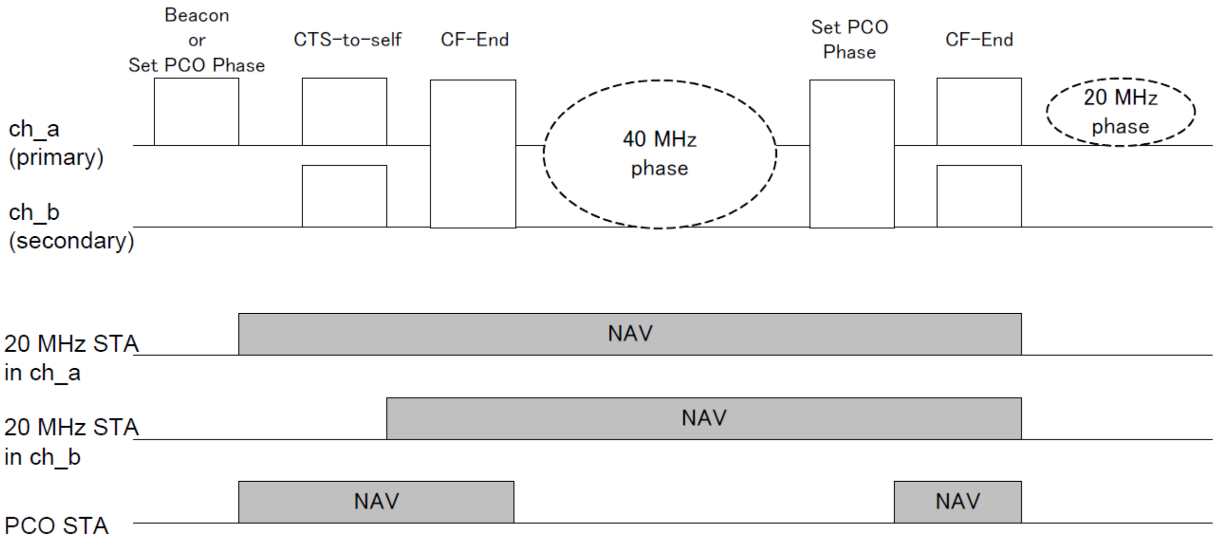
<table>
<tr><th>Claim 17 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>


Table n49—Protection requirements for Operating Modes of 1 and 3

<table>
<tr><th>Type of Transmission</th><th>Use Protection = 0 or ERP IE is not present (Operating Mode = 3)</th><th>Use Protection = 1 (Operating Mode = 1 or 3)</th></tr>
<tr><td>20 MHz transmission:</td><td>HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.</td><td>All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions.
The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.</td></tr>
<tr><td>40 MHz transmission:</td><td>HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.</td><td>All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions.
The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.</td></tr>
</table>

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.
NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).
</td></tr>
</table>

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

Claim 17 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

Claim 17 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t \right) \right\} \quad (20\text{-}1)$ where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

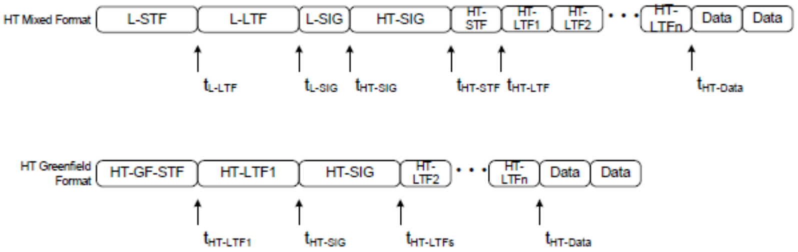


Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right)T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}\left(t - t_{HT-DATA}\right) \end{aligned} \tag{20-2}$$

where

$t_{L-LTF} = T_{L-STF}$

$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$

$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$

$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1}) \\ & + r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2) T_{HT-LTFs}) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \quad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\text{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\text{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j 2\pi k \Delta_F t) \quad (20\text{-}4)$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \quad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \quad (20\text{-}6)$$

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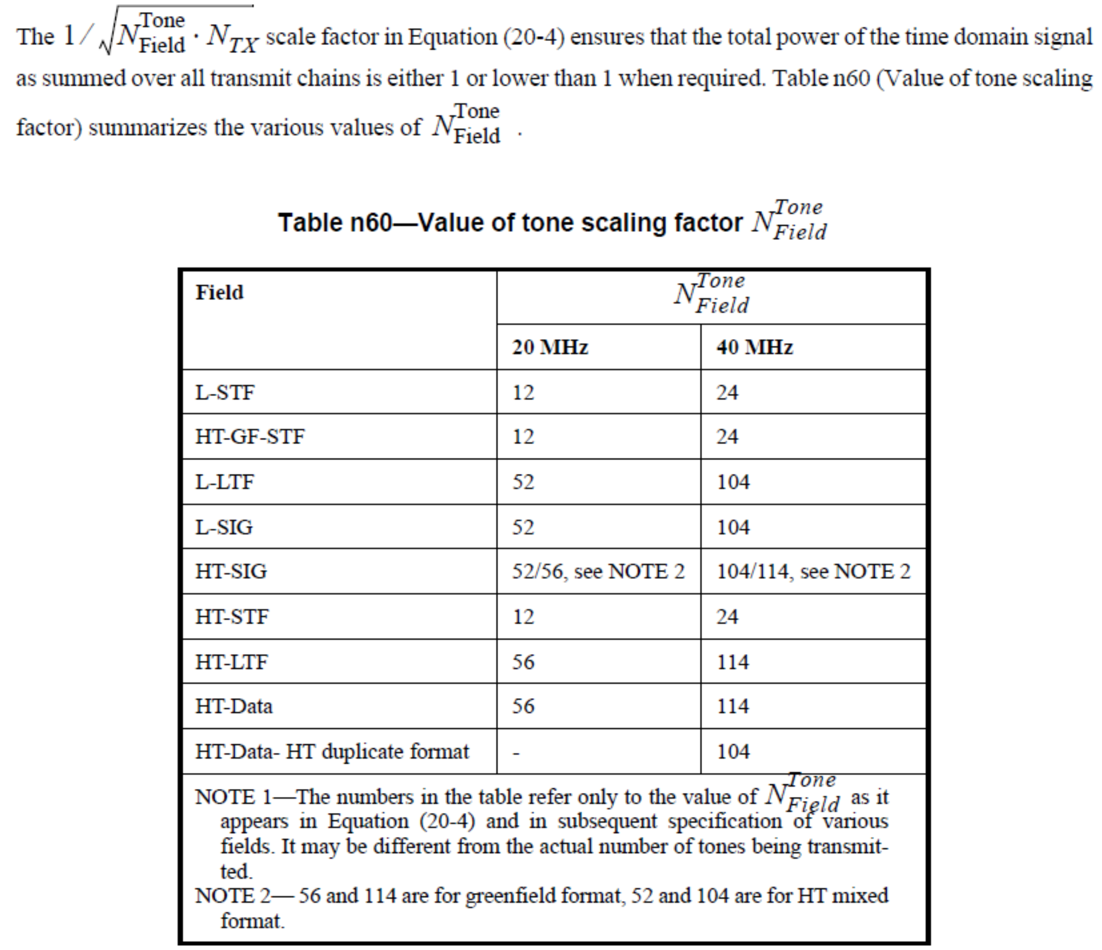

The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	40 MHz
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

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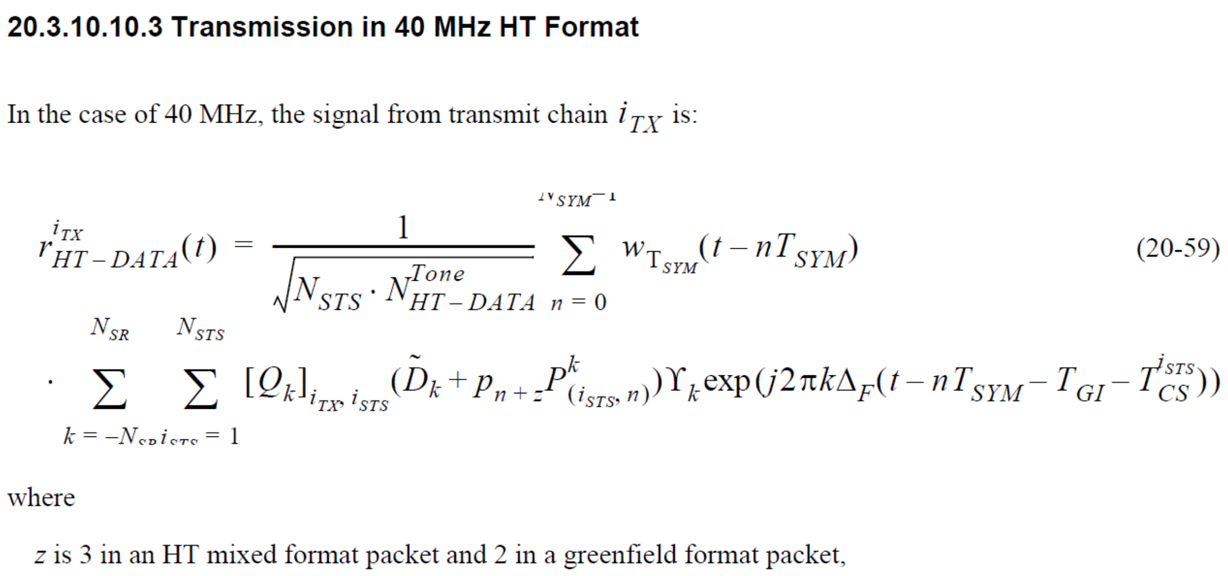
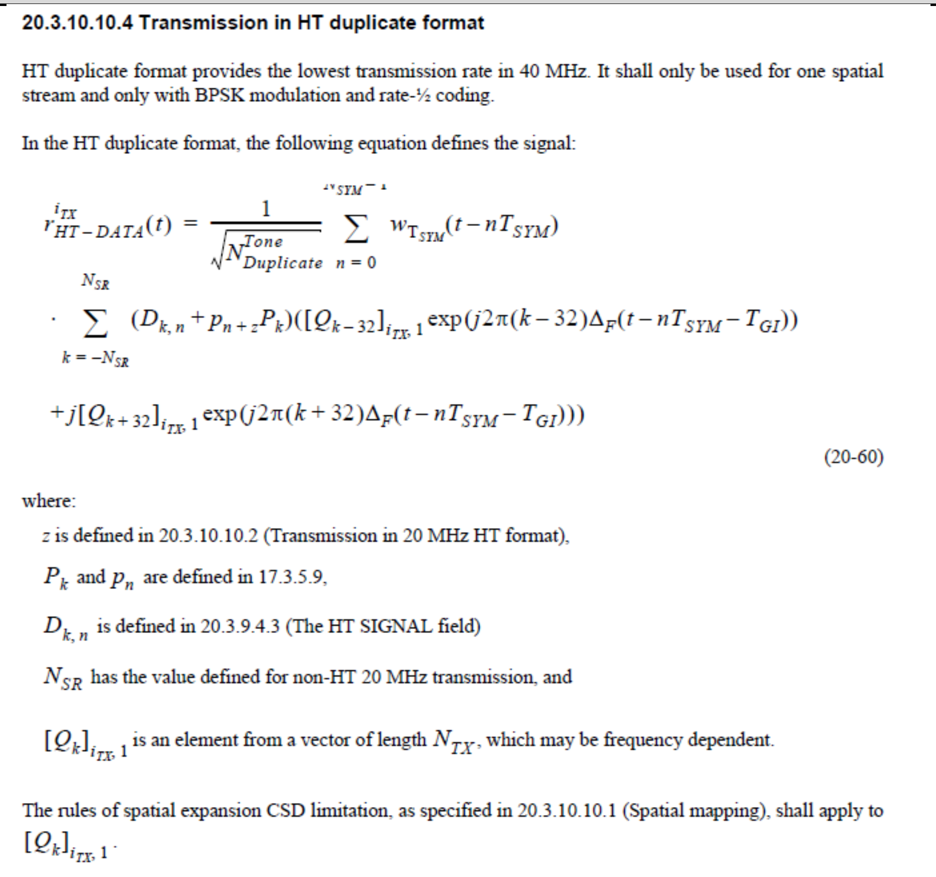
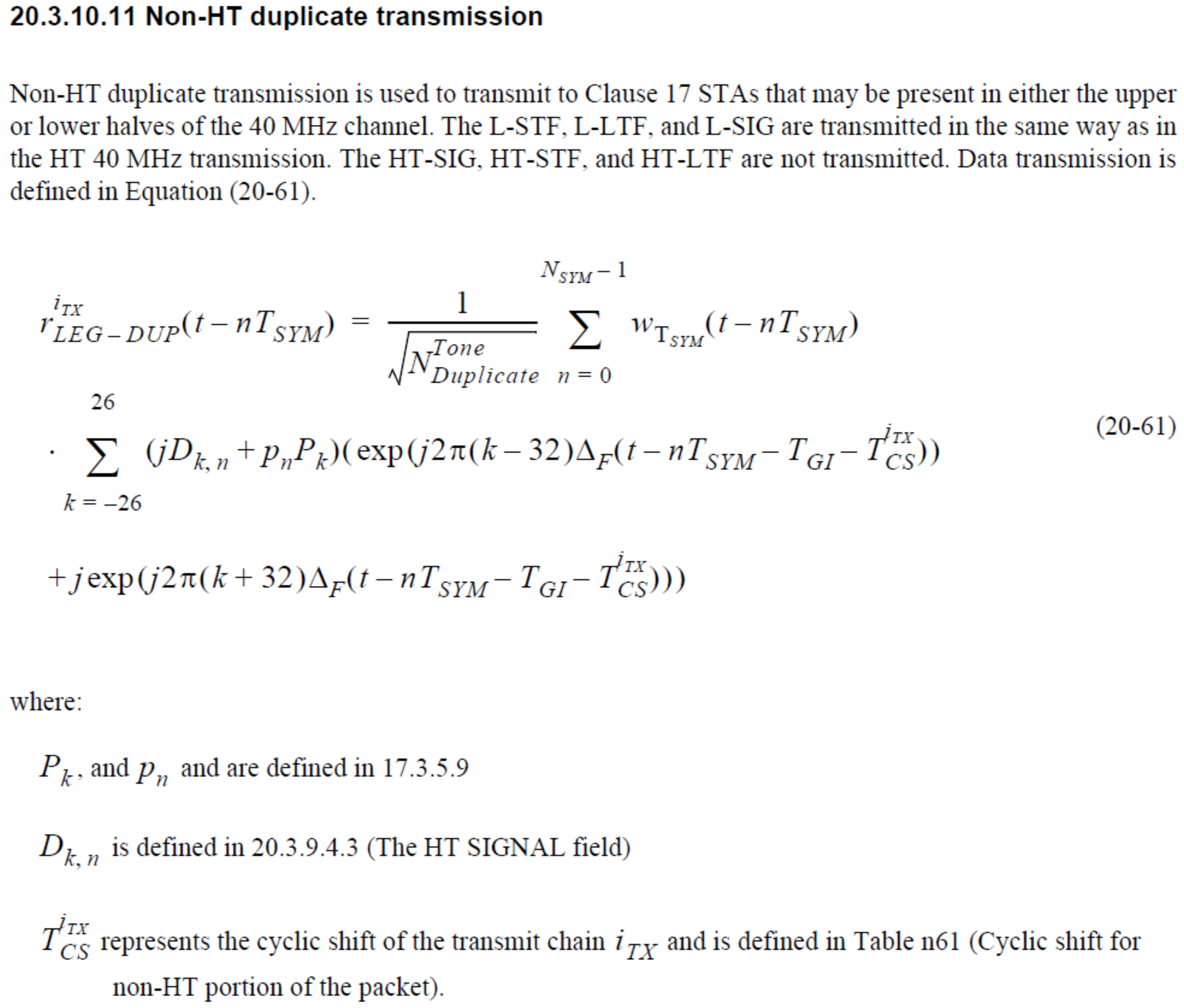
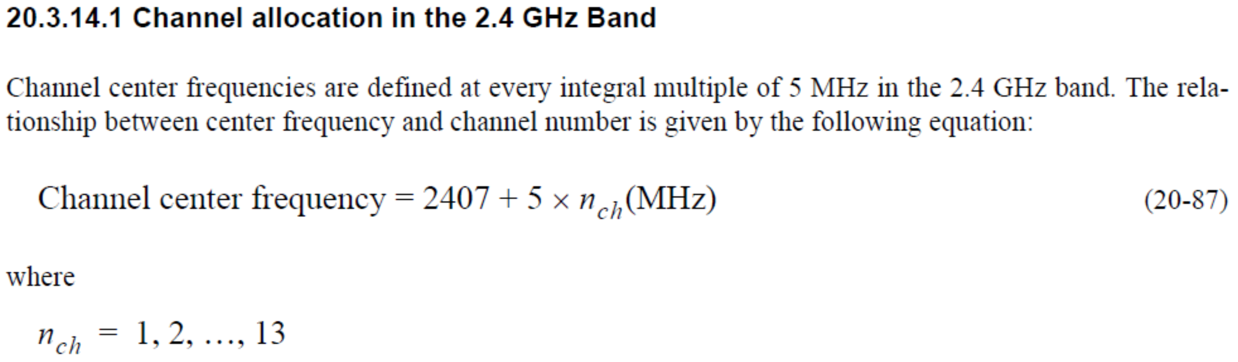
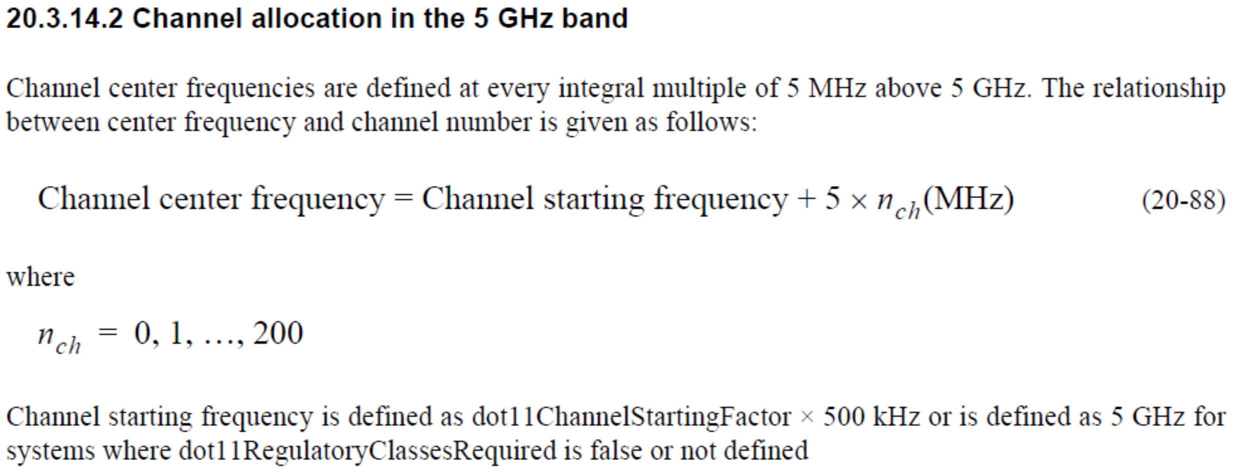
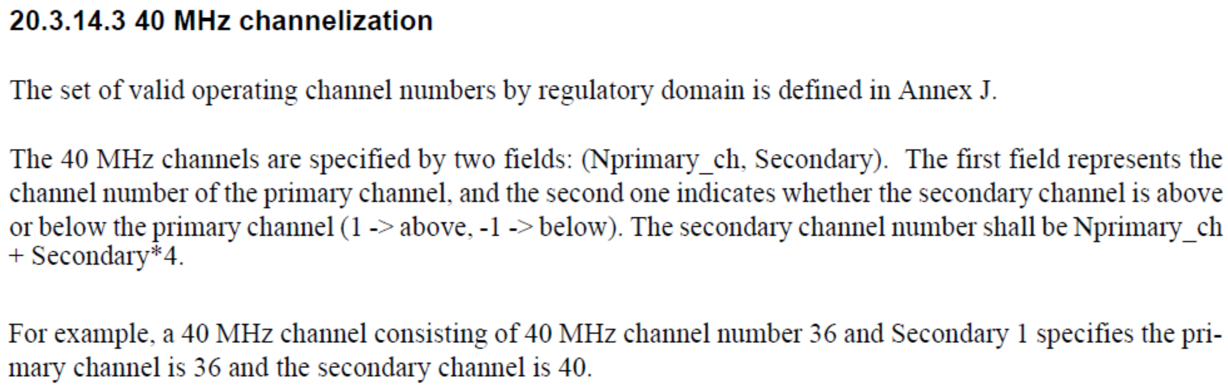
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{\mathrm{T}_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P_{(i_{STS},n)}^k) \exp(j 2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (20-58) where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

Claim 17 of the '802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $$r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS} \cdot N^{Tone}_{HT-DATA}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P^k_{(i_{STS}, n)}) \Upsilon_k \exp(j 2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T^{i_{STS}}_{CS})) \quad (20\text{-}59)$$ where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n}+p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI})) + j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r^{i_{TX}}_{LEG-DUP}(t - nT_{SYM}) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n} + p_n P_k)(\exp(j2\pi(k-32)\Delta_F(t - nT_{SYM} - T_{GI} - T^{i_{TX}}_{CS})) + j\exp(j2\pi(k+32)\Delta_F(t - nT_{SYM} - T_{GI} - T^{i_{TX}}_{CS})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T^{i_{TX}}_{CS}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $$\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz}) \quad (20\text{-}87)$$ where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $$\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz}) \quad (20\text{-}88)$$ where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

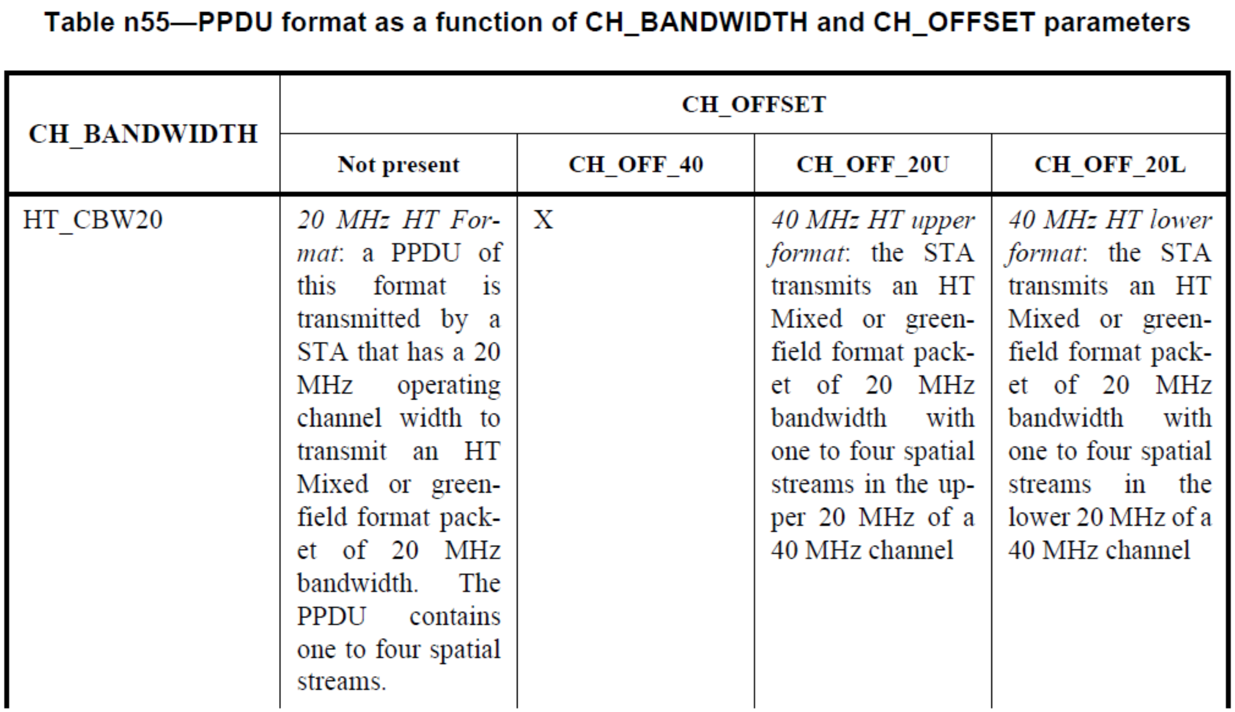
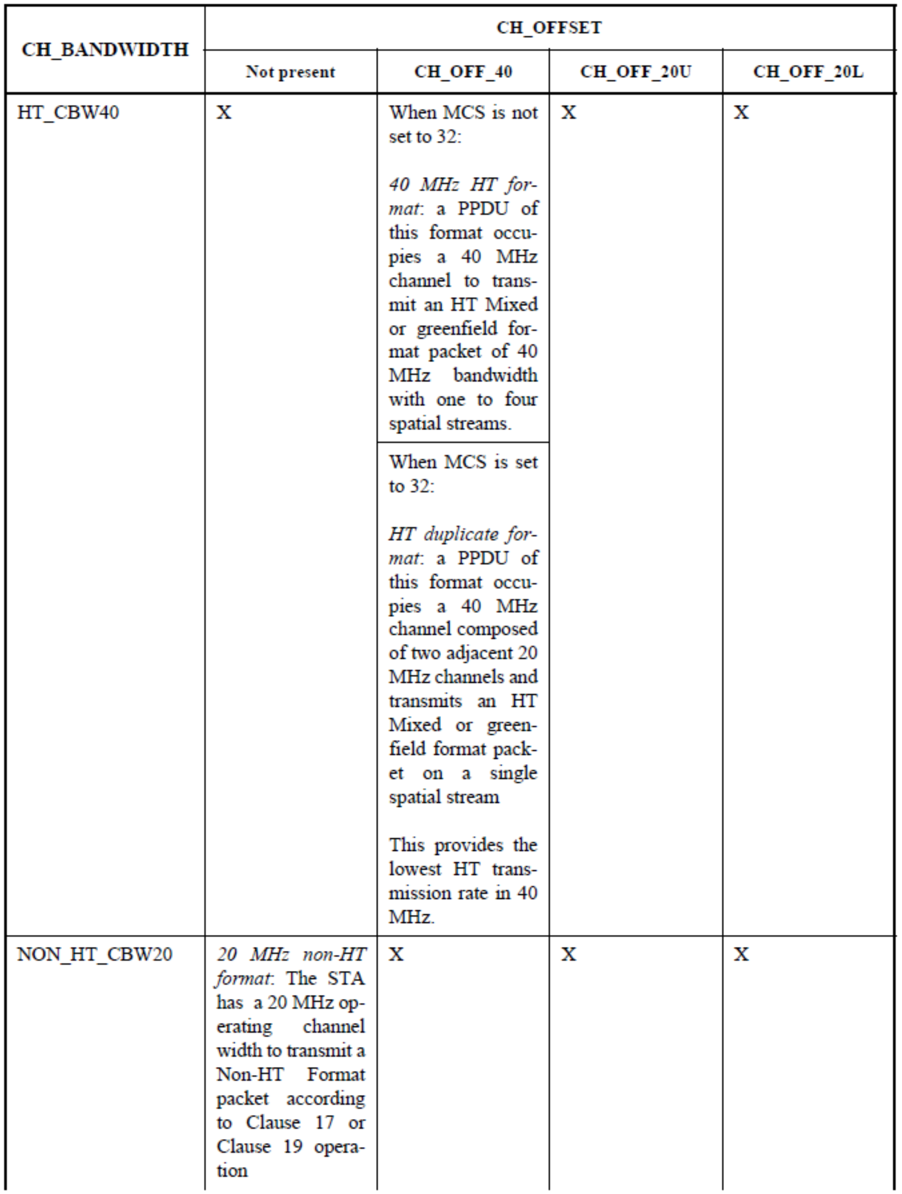
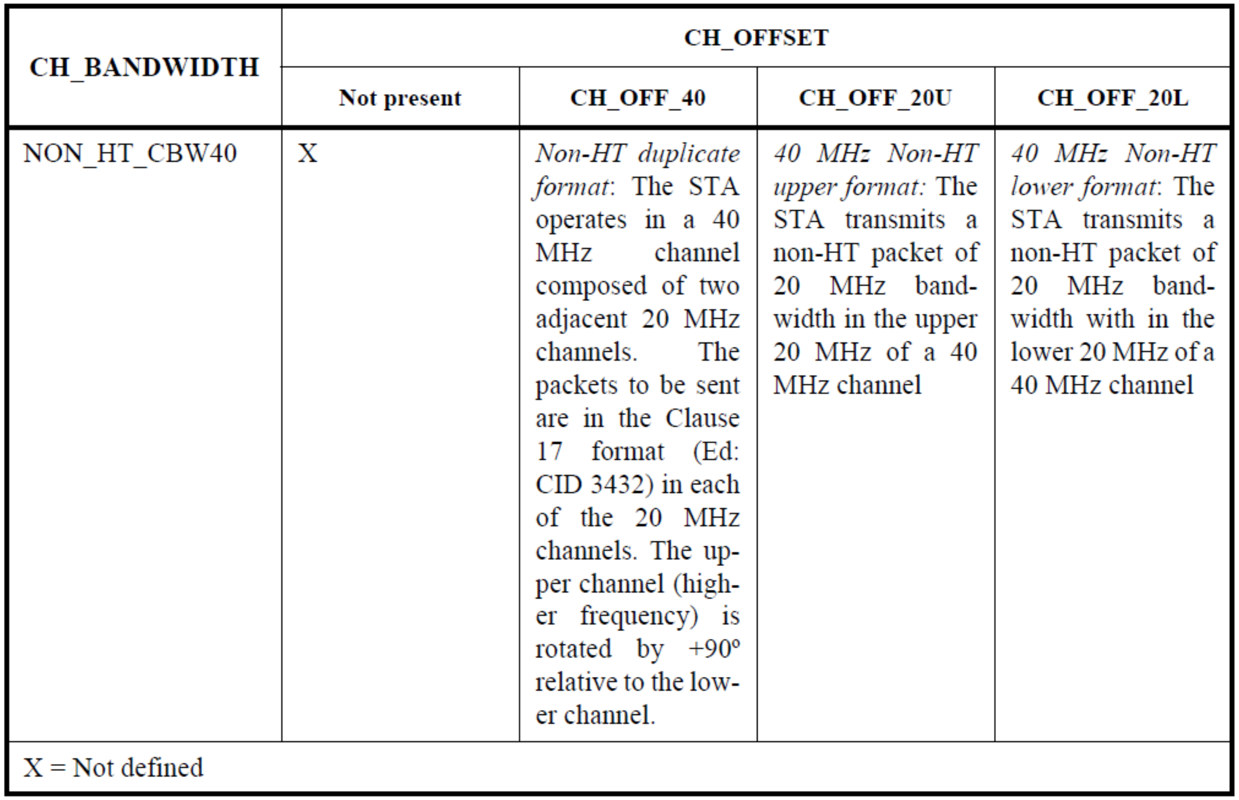
Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.20.3 

Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel



CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

<table>
<tr><th>Claim 17 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>NON_HT_CBW40</td><td>X</td><td><i>Non-HT duplicate format</i>: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.</td><td><i>40 MHz Non-HT upper format:</i> The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel</td><td><i>40 MHz Non-HT lower format</i>: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel</td></tr>
<tr><td colspan="5">X = Not defined</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n55
</td></tr>
</table>

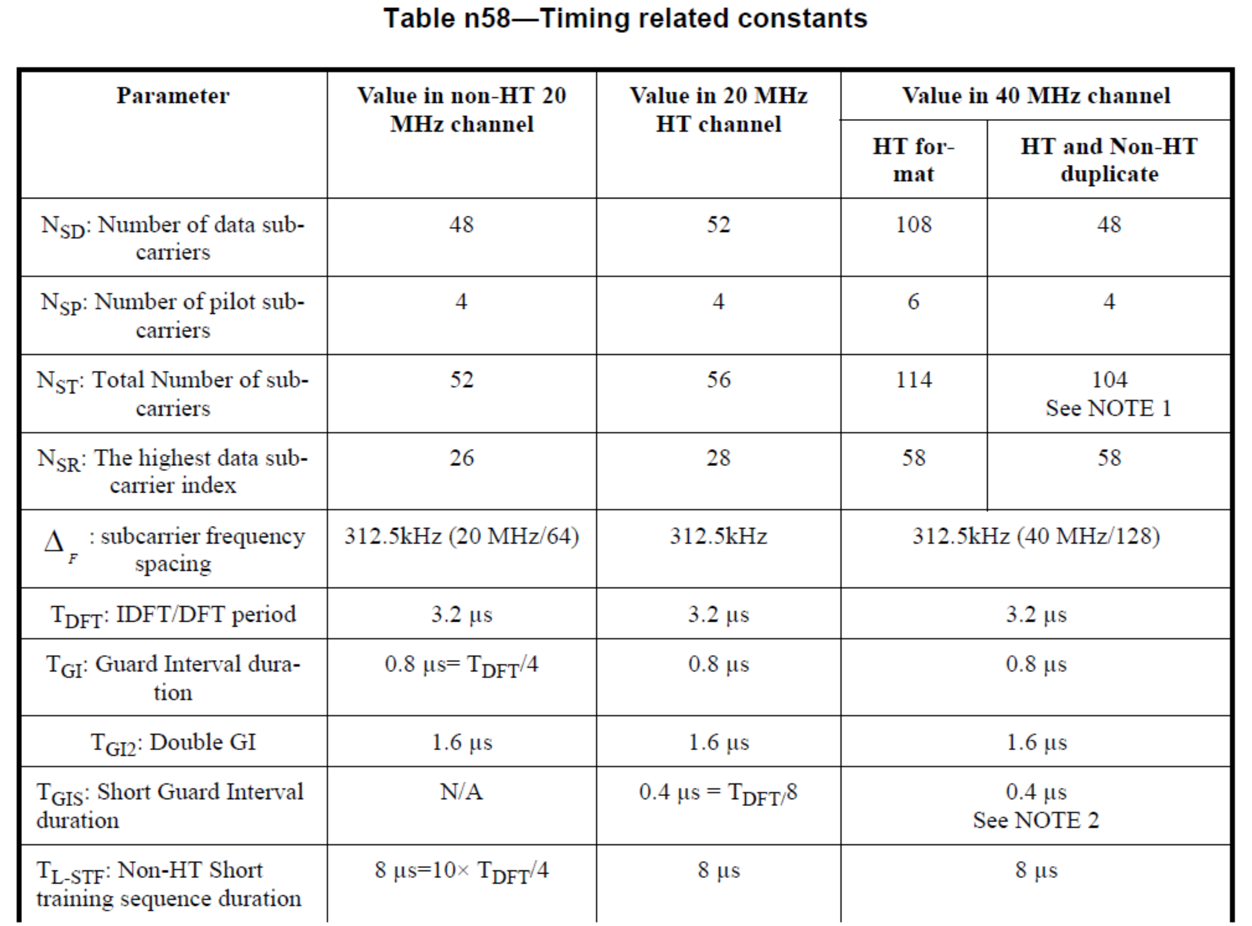
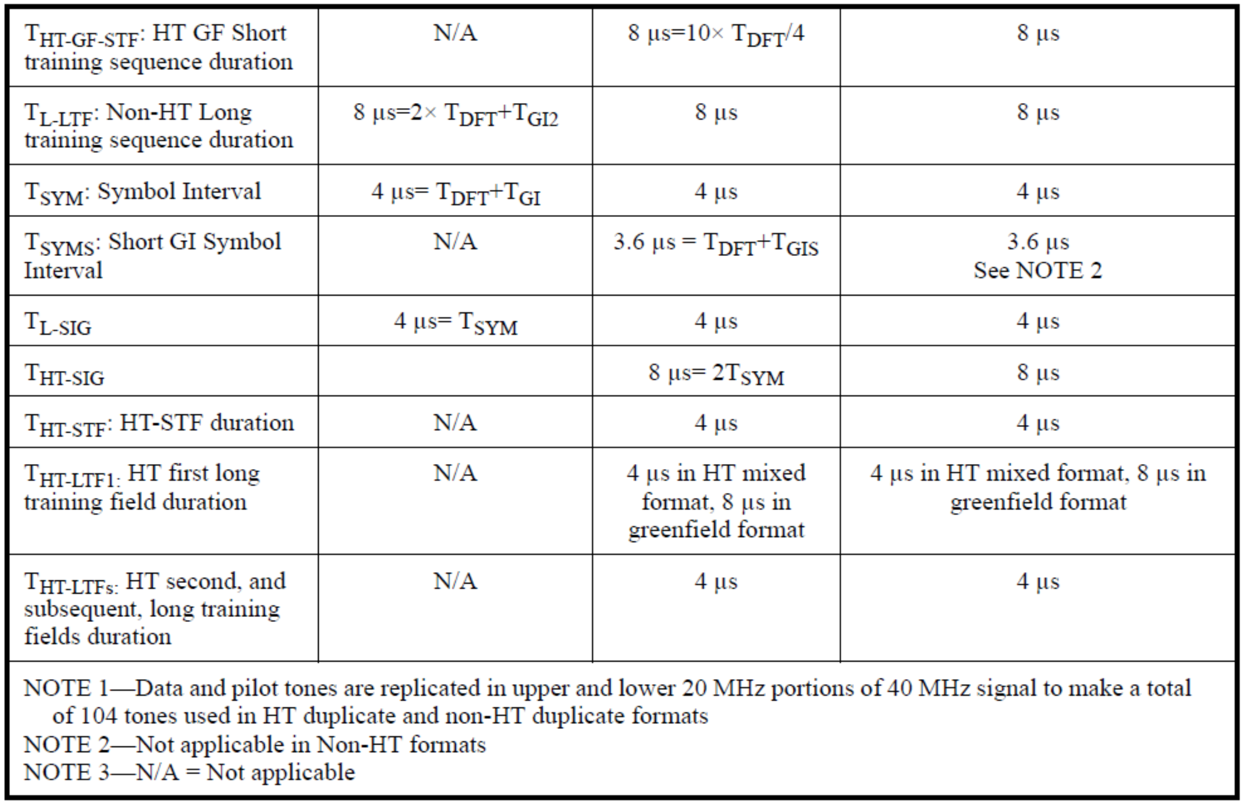
Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	

Table n58—Timing related constants

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 μs	3.2 μs	3.2 μs	
T_{GI}: Guard Interval duration	0.8 μs= $T_{DFT}/4$	0.8 μs	0.8 μs	
T_{GI2}: Double GI	1.6 μs	1.6 μs	1.6 μs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 μs = $T_{DFT}/8$	0.4 μs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 μs=10× $T_{DFT}/4$	8 μs	8 μs	

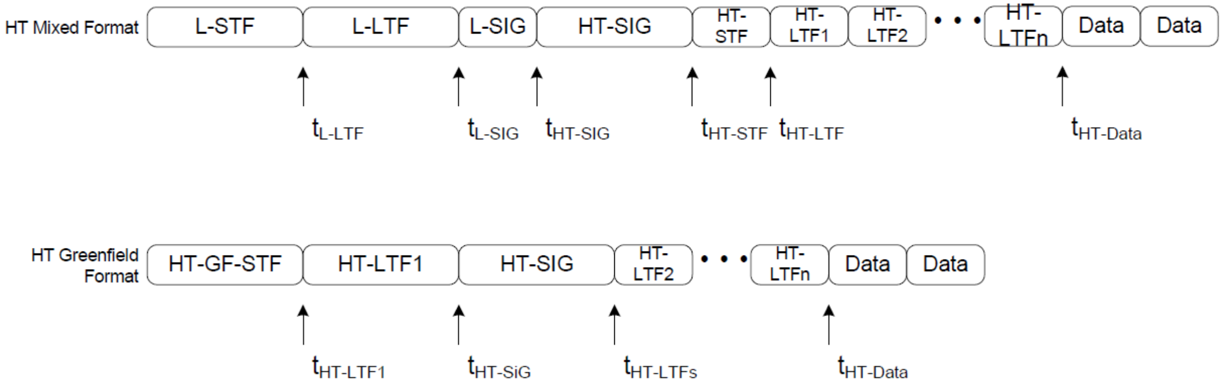
Claim 17 of the '802 Patent	**Prior Art Reference – 802.11n D2.0**



$T_{HT\text{-}GF\text{-}STF}$: HT GF Short training sequence duration	N/A	8 µs=10× $T_{DFT}/4$	8 µs
$T_{L\text{-}LTF}$: Non-HT Long training sequence duration	8 µs=2× $T_{DFT}+T_{GI2}$	8 µs	8 µs
T_{SYM}: Symbol Interval	4 µs= $T_{DFT}+T_{GI}$	4 µs	4 µs
T_{SYMS}: Short GI Symbol Interval	N/A	3.6 µs = $T_{DFT}+T_{GIS}$	3.6 µs See NOTE 2
$T_{L\text{-}SIG}$	4 µs= T_{SYM}	4 µs	4 µs
$T_{HT\text{-}SIG}$		8 µs= $2T_{SYM}$	8 µs
$T_{HT\text{-}STF}$: HT-STF duration	N/A	4 µs	4 µs
$T_{HT\text{-}LTF1}$: HT first long training field duration	N/A	4 µs in HT mixed format, 8 µs in greenfield format	4 µs in HT mixed format, 8 µs in greenfield format
$T_{HT\text{-}LTFs}$: HT second, and subsequent, long training fields duration	N/A	4 µs	4 µs

NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable

See, e.g., 802.11n D2.0 Table n58

Claim 17 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.
[17.4] a second digital-to-analog converter for receiving the second digital signal and converting the second digital signal into a second analog signal, the second analog signal carrying the second	802.11n D2.0 discloses "a second digital-to-analog converter for receiving the second digital signal and converting the second digital signal into a second analog signal, the second analog signal carrying the second data across a second frequency range." See, e.g.: **high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
data across a second frequency range;	**non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

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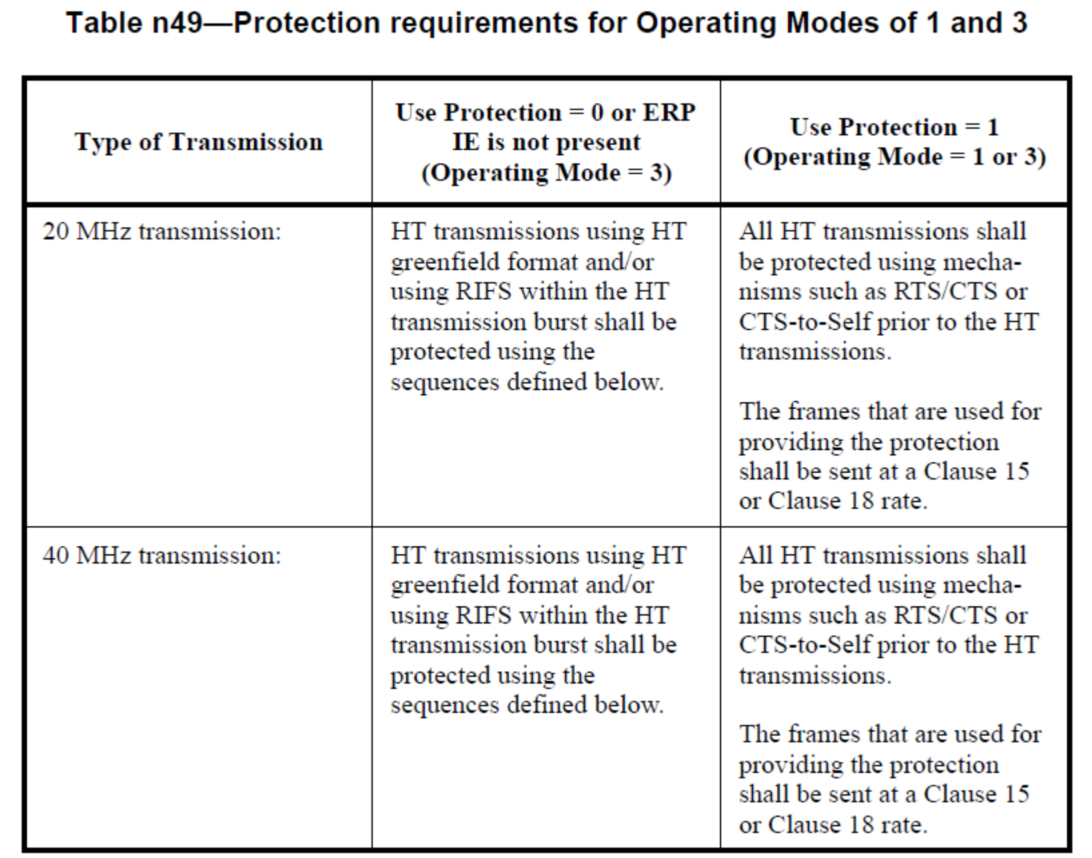

Table n49—Protection requirements for Operating Modes of 1 and 3

Type of Transmission	Use Protection = 0 or ERP IE is not present (Operating Mode = 3)	Use Protection = 1 (Operating Mode = 1 or 3)
20 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.
40 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:

a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:

1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19

2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.

NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).

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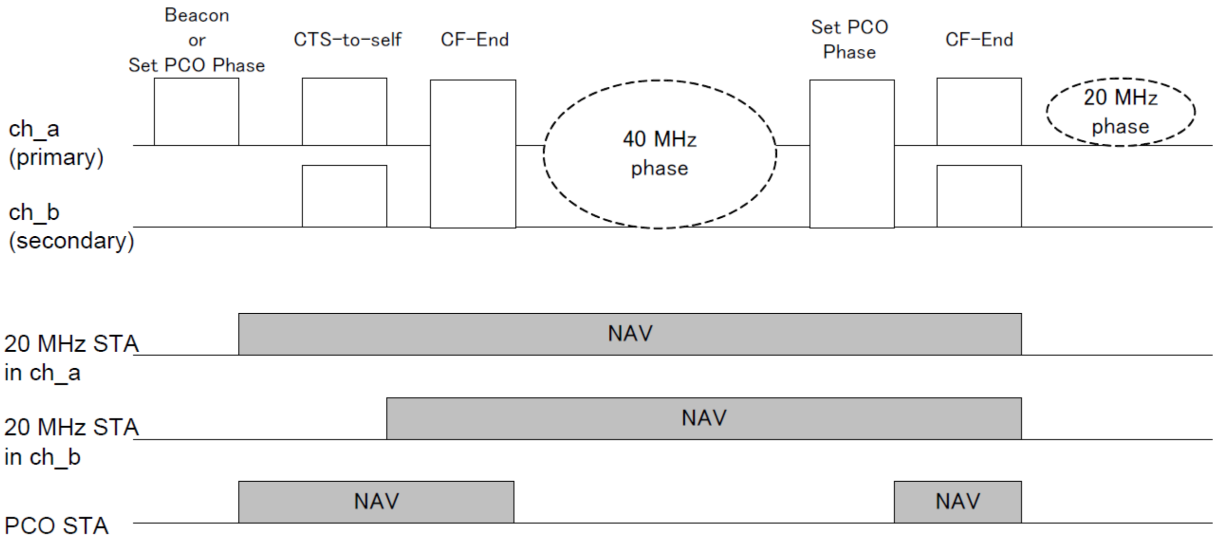
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

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	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

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	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

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	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

Claim 17 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t \right) \right\}$ (20-1) where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

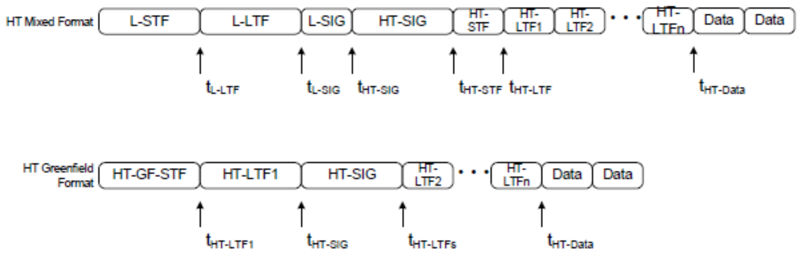


Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right)T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}\left(t - t_{HT-DATA}\right) \end{aligned} \qquad (20\text{-}2)$$

where

$$t_{L-LTF} = T_{L-STF}$$

$$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$$

$$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$$

$$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1}) \\ & + r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2) T_{HT-LTFs}) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \qquad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\text{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\text{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_k \Upsilon_k X_k^{(i_{TX})} \exp(j 2\pi k \Delta_F t) \qquad (20\text{-}4)$$

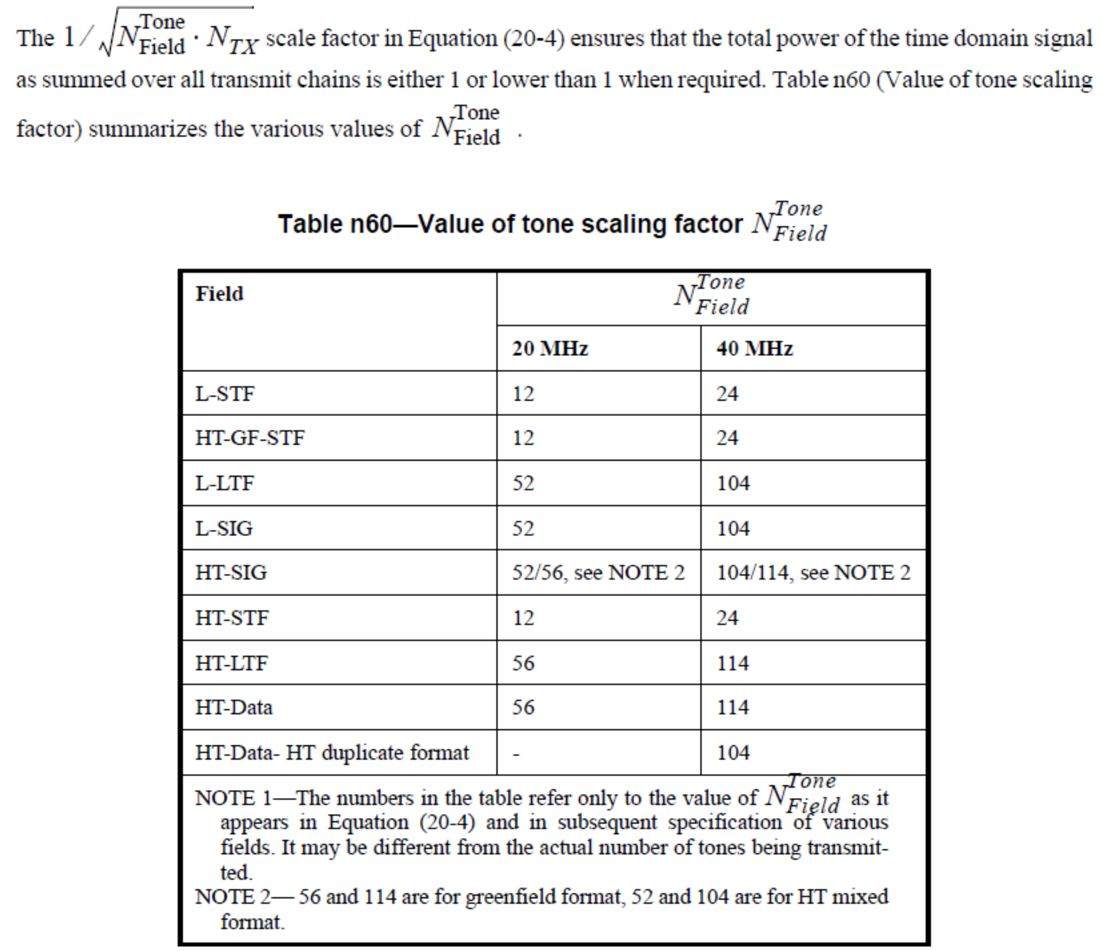
This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \qquad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \qquad (20\text{-}6)$$

Claim 17 of the '802 Patent	Prior Art Reference – 802.11n D2.0



The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	40 MHz
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

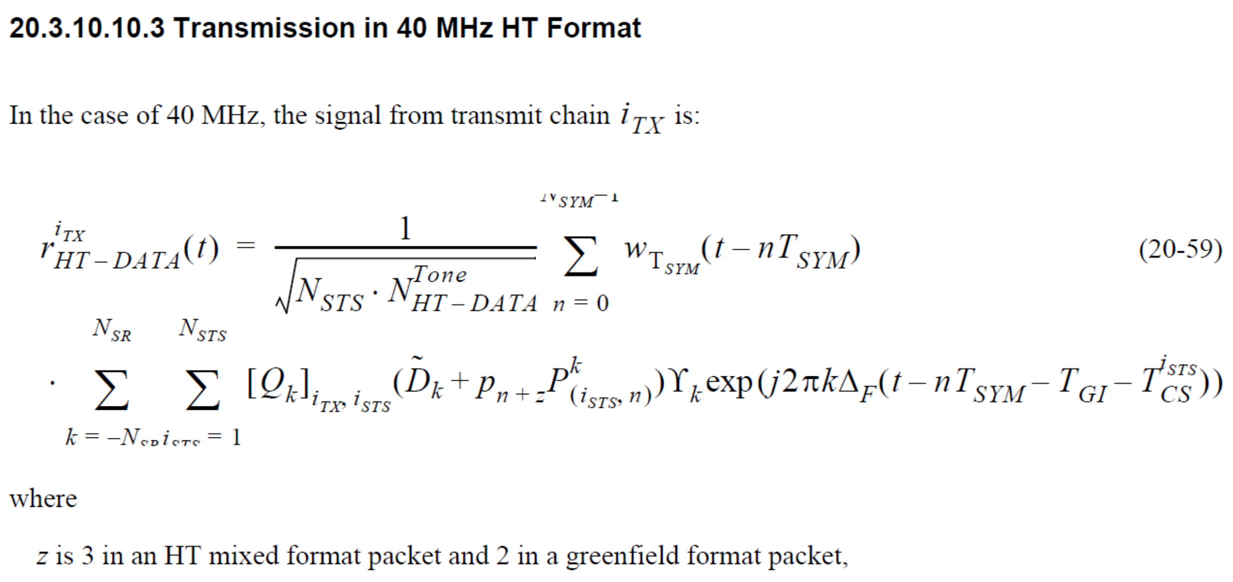
NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

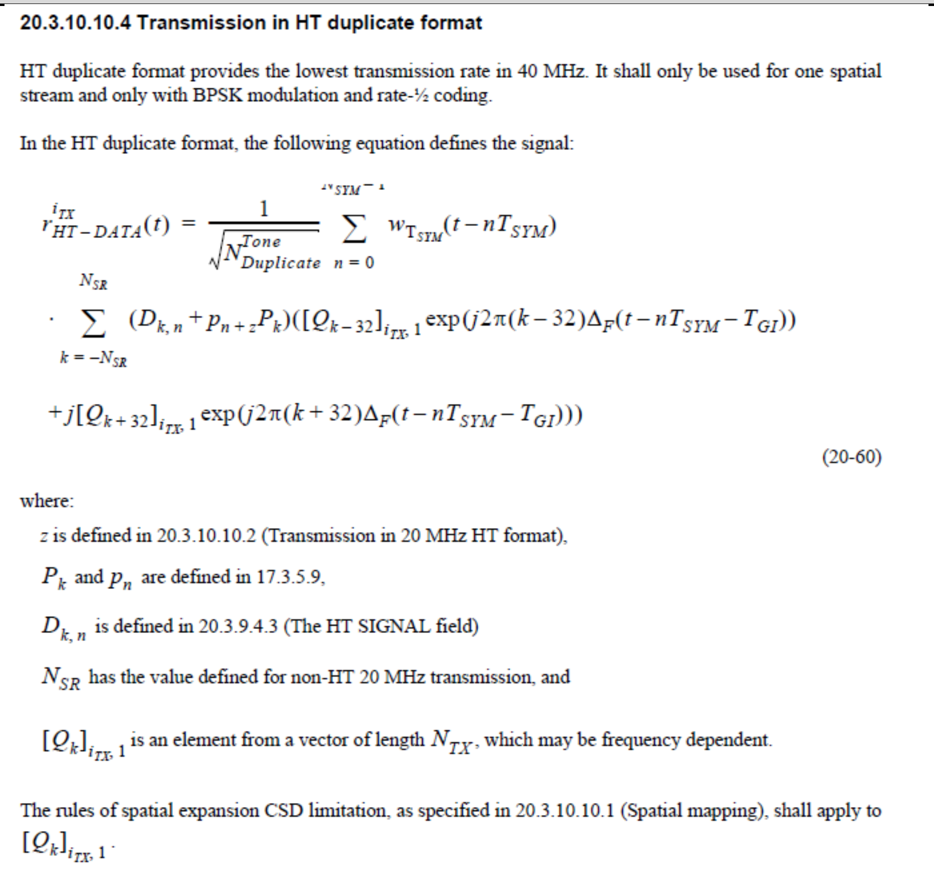
See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

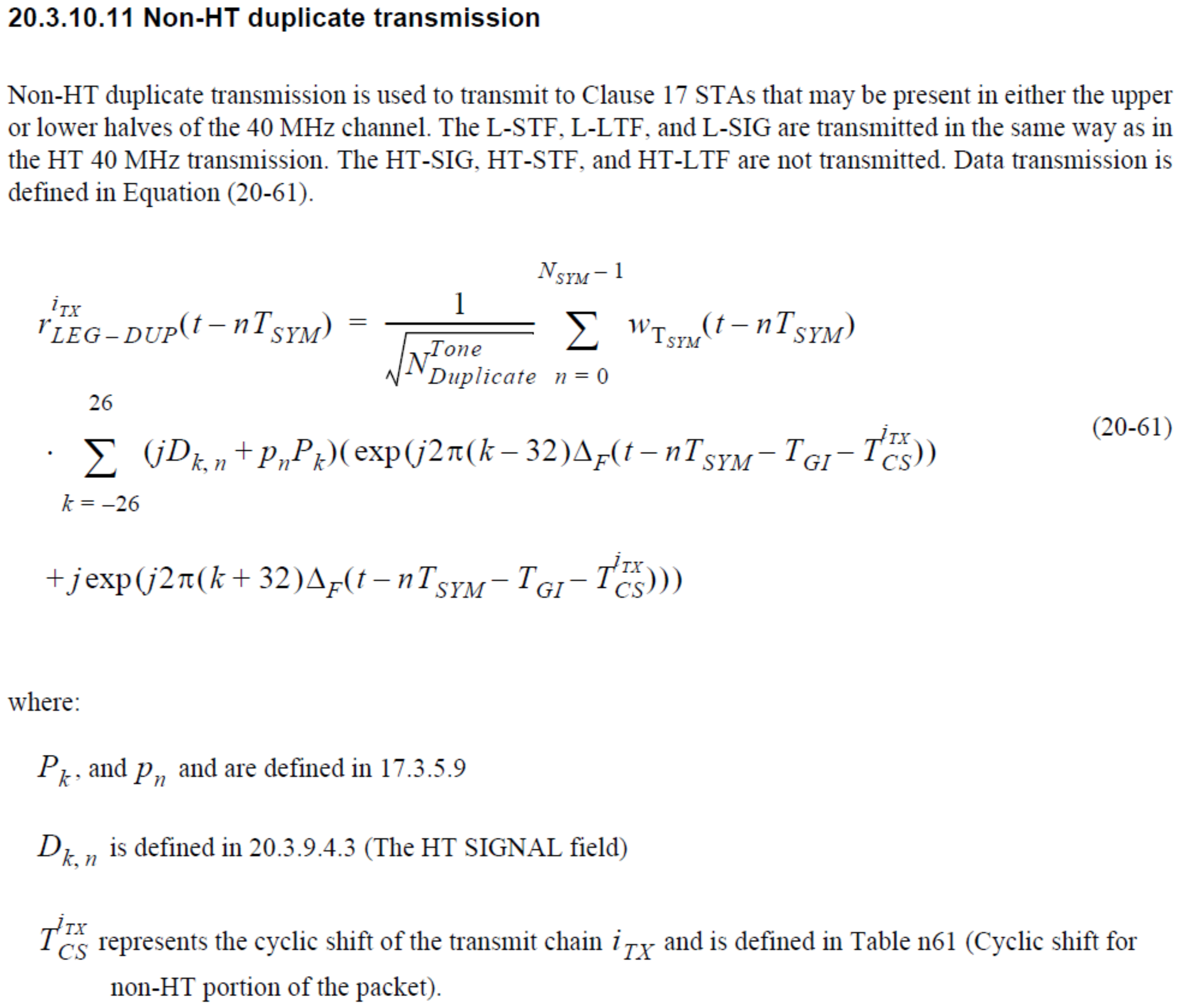
20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

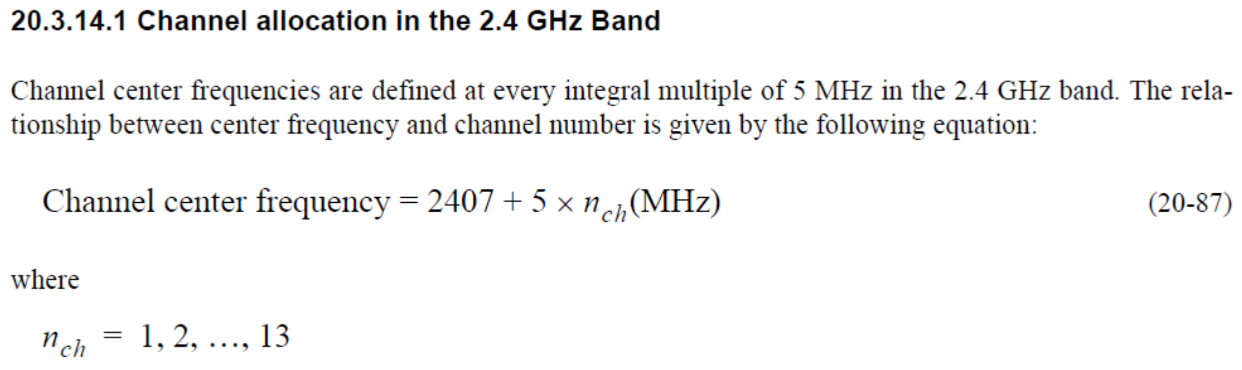
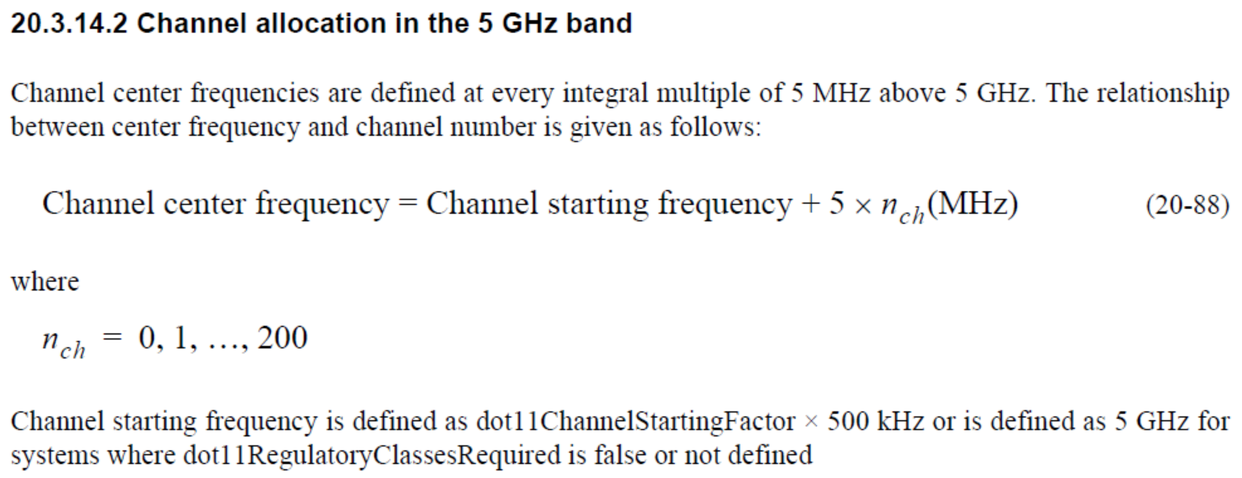
When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

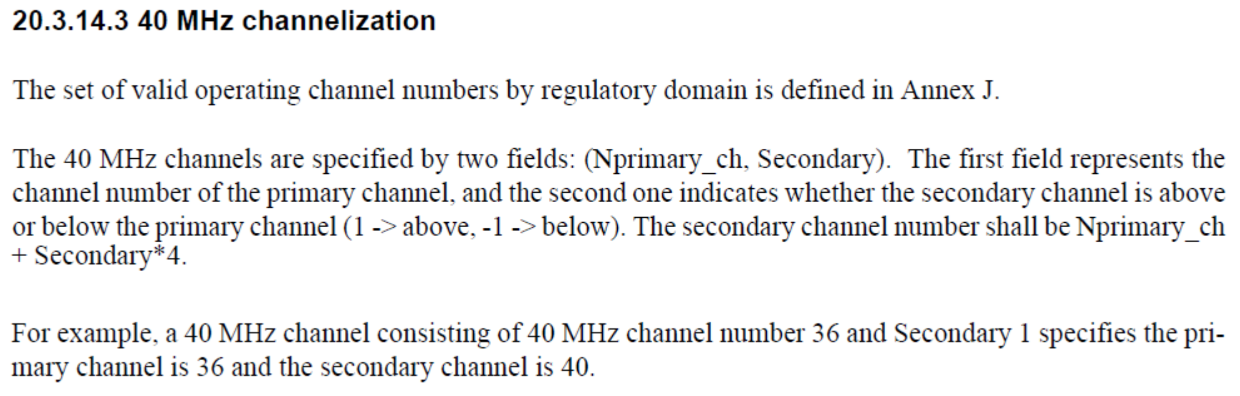
Claim 17 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P_{(i_{STS},n)}^{k}) \exp(j 2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (20-58) where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $$r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS} \cdot N^{Tone}_{HT-DATA}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P^k_{(i_{STS}, n)}) \Upsilon_k \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T^{i_{STS}}_{CS})) \quad (20\text{-}59)$$ where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

Claim 17 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n}+p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1}\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI})) + j[Q_{k+32}]_{i_{TX},1}\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r^{i_{TX}}_{LEG-DUP}(t-nT_{SYM}) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n}+p_nP_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T^{i_{TX}}_{CS}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 17 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz})$ (20-87) where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz})$ (20-88) where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 17 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

Claim 17 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.20.3

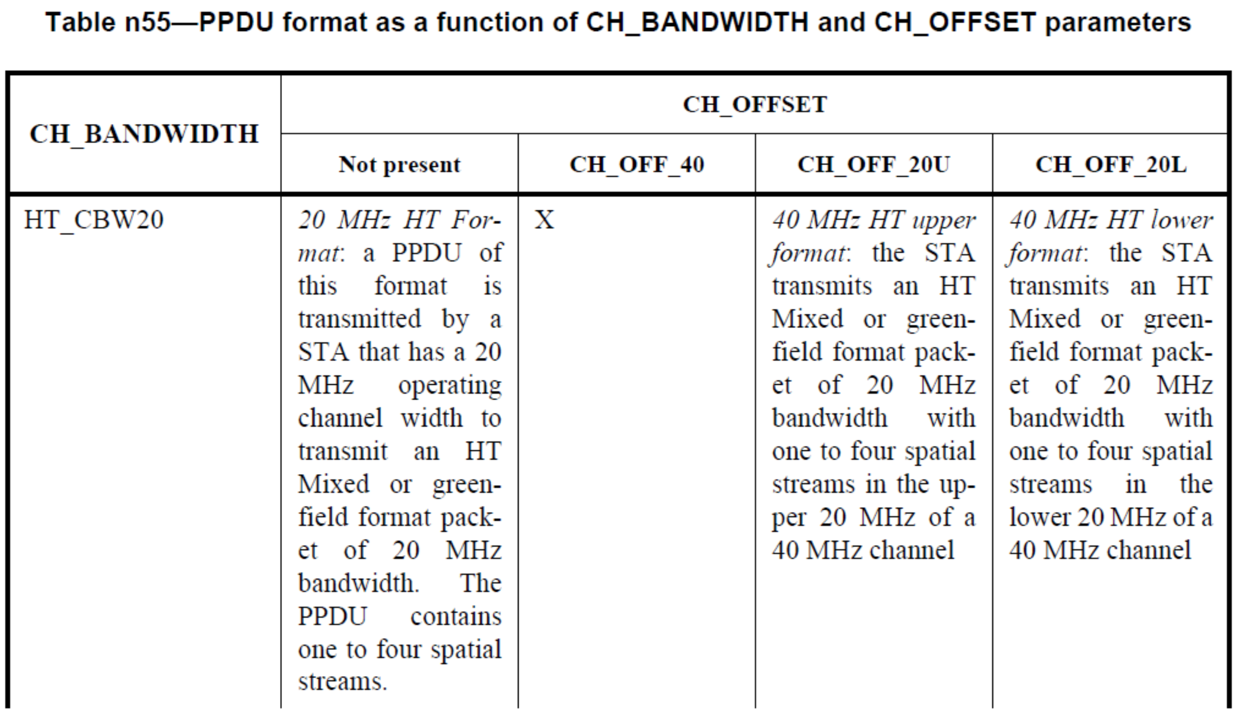
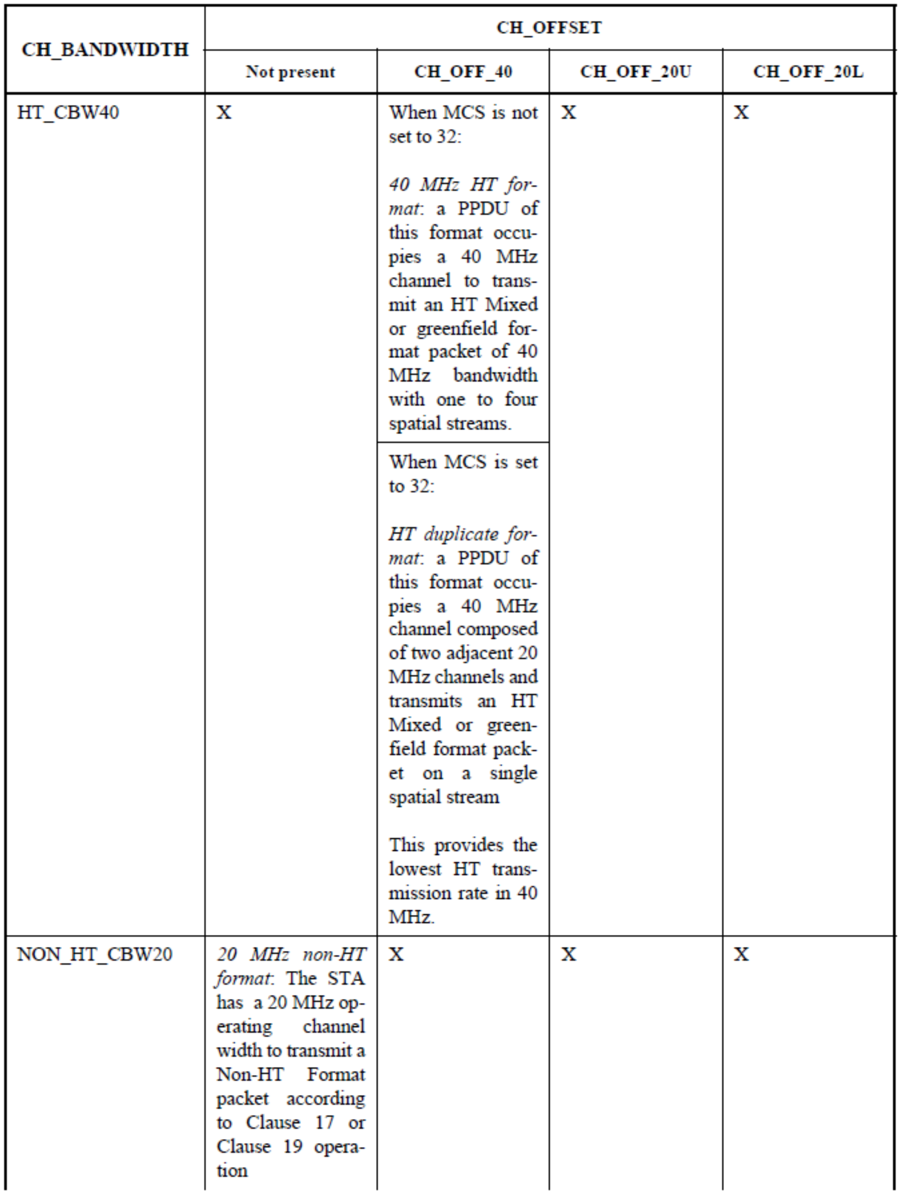


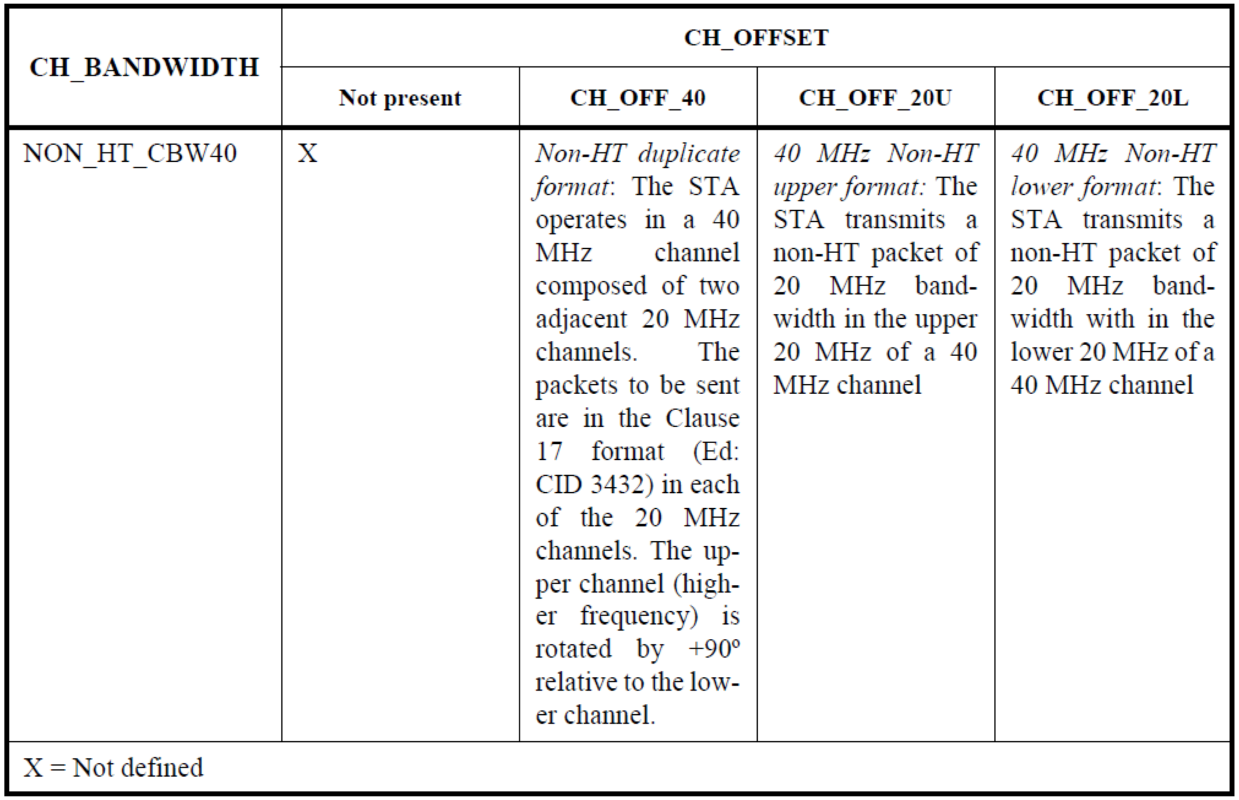
Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

CH_BANDWIDTH	**CH_OFFSET**			
	Not present	**CH_OFF_40**	**CH_OFF_20U**	**CH_OFF_20L**
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel



CH_BANDWIDTH	**CH_OFFSET**			
	Not present	**CH_OFF_40**	**CH_OFF_20U**	**CH_OFF_20L**
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams.	X	X
		When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.		
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

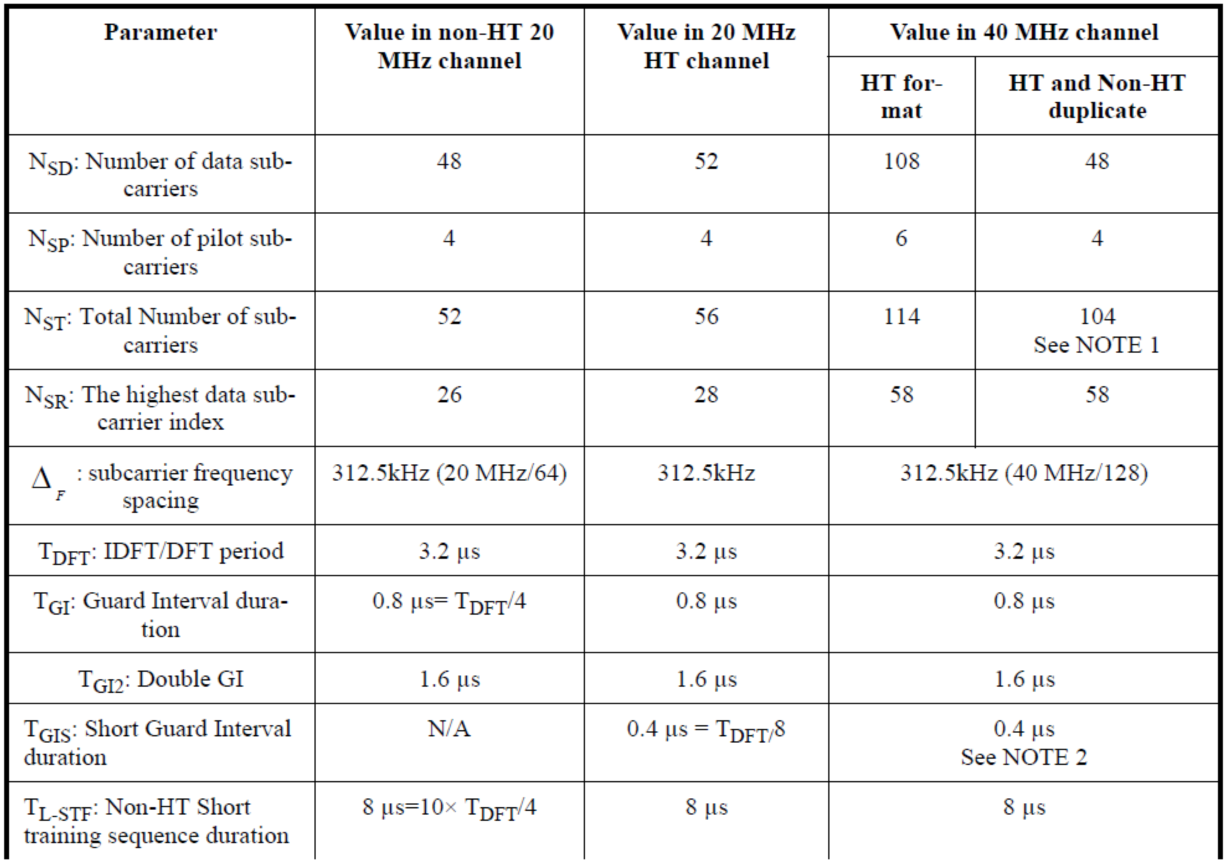
Claim 17 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**



CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
NON_HT_CBW40	X	*Non-HT duplicate format*: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.	*40 MHz Non-HT upper format:* The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel	*40 MHz Non-HT lower format*: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel

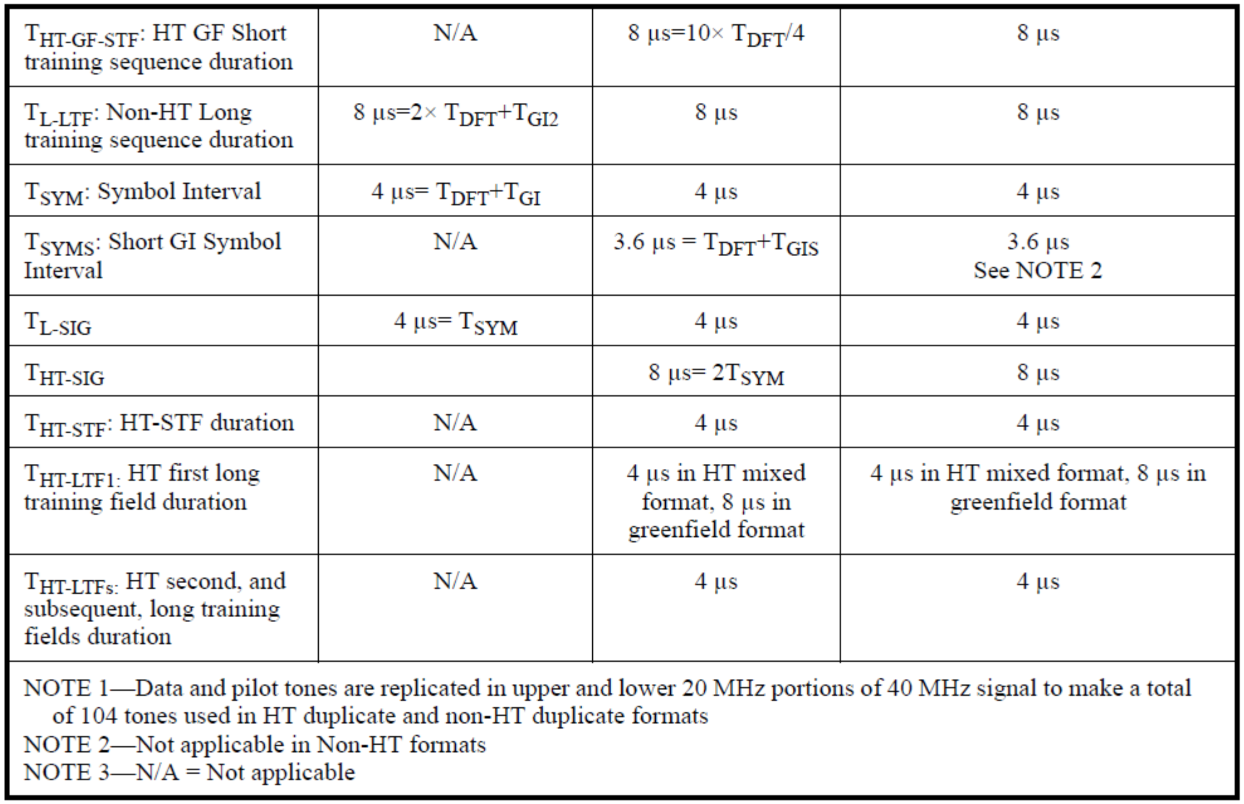
X = Not defined

See, e.g., 802.11n D2.0 Table n55

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	Table n58—Timing related constants 

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

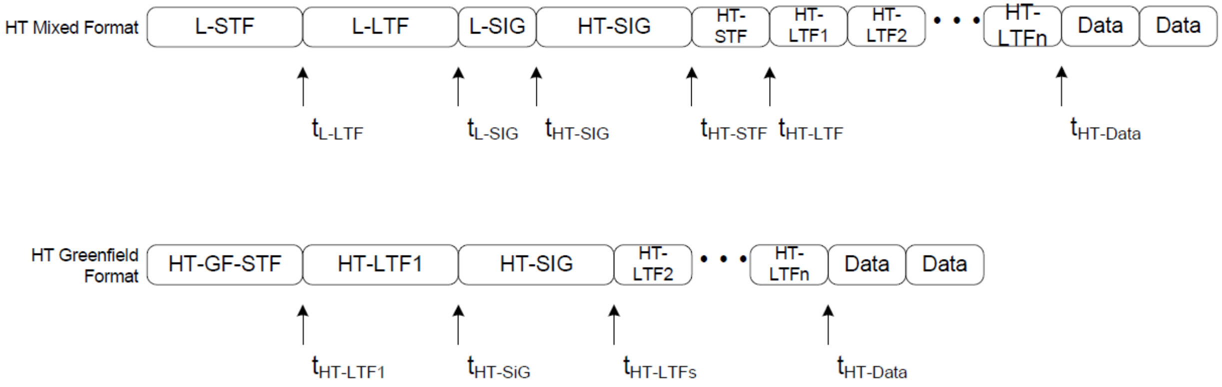
Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0



$T_{HT\text{-}GF\text{-}STF}$: HT GF Short training sequence duration	N/A	8 μs=10× $T_{DFT}/4$	8 μs
$T_{L\text{-}LTF}$: Non-HT Long training sequence duration	8 μs=2× $T_{DFT}+T_{GI2}$	8 μs	8 μs
T_{SYM}: Symbol Interval	4 μs= $T_{DFT}+T_{GI}$	4 μs	4 μs
T_{SYMS}: Short GI Symbol Interval	N/A	3.6 μs = $T_{DFT}+T_{GIS}$	3.6 μs See NOTE 2
$T_{L\text{-}SIG}$	4 μs= T_{SYM}	4 μs	4 μs
$T_{HT\text{-}SIG}$		8 μs= $2T_{SYM}$	8 μs
$T_{HT\text{-}STF}$: HT-STF duration	N/A	4 μs	4 μs
$T_{HT\text{-}LTF1}$: HT first long training field duration	N/A	4 μs in HT mixed format, 8 μs in greenfield format	4 μs in HT mixed format, 8 μs in greenfield format
$T_{HT\text{-}LTFs}$: HT second, and subsequent, long training fields duration	N/A	4 μs	4 μs

NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable

See, e.g., 802.11n D2.0 Table n58

Claim 17 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.
[17.5] a first up-converter circuit having a first input coupled to receive the first analog signal and a second input coupled to receive a first modulation signal having a first RF frequency, wherein the first up-converter outputs	802.11n D2.0 discloses "a first up-converter circuit having a first input coupled to receive the first analog signal and a second input coupled to receive a first modulation signal having a first RF frequency, wherein the first up-converter outputs a first up-converted analog signal comprising a first up-converted frequency range from the first RF frequency minus one-half the first frequency range to the first RF frequency plus one-half the first frequency range." See, e.g.: **high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate.

Claim 17 of the '802 Patent	Prior Art Reference – 802.11n D2.0
a first up-converted analog signal comprising a first up-converted frequency range from the first RF frequency minus one-half the first frequency range to the first RF frequency plus one-half the first frequency range;	See, e.g., 802.11n D2.0 § 3.n19 **non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

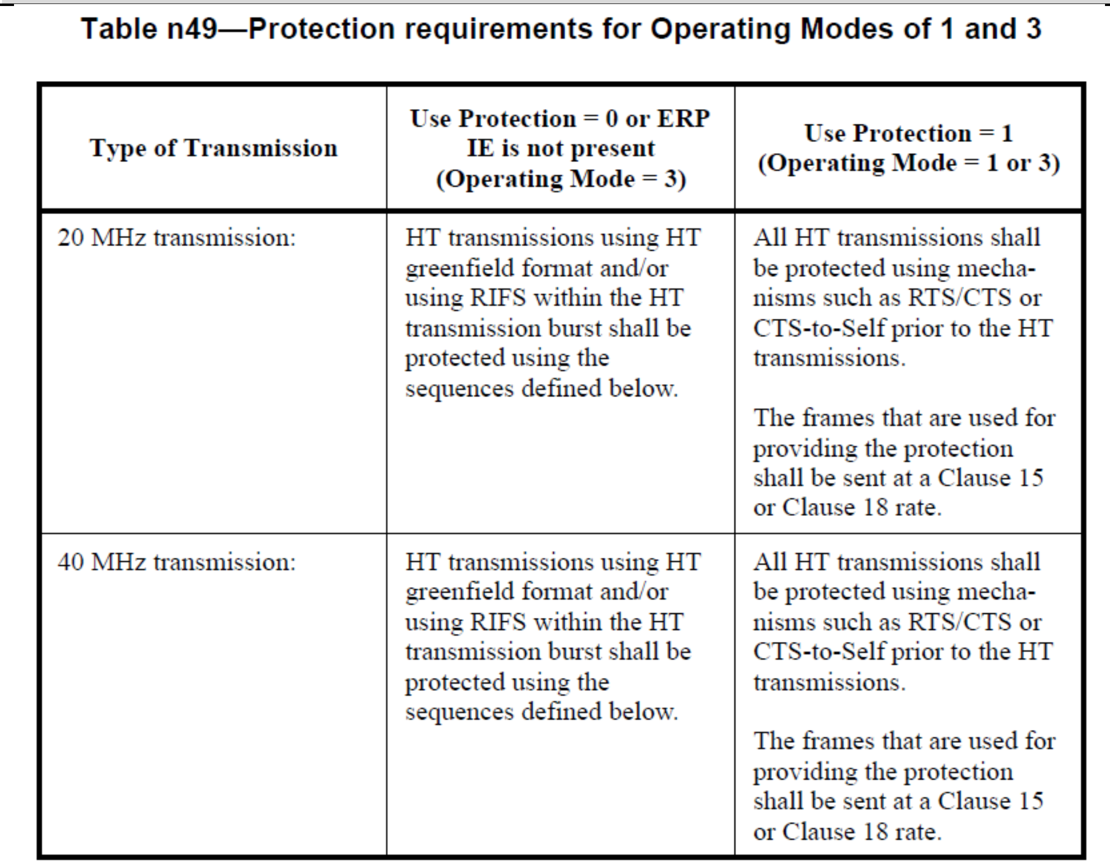
<table>
<tr><th>Claim 17 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>


Table n49—Protection requirements for Operating Modes of 1 and 3

<table>
<tr><th>Type of Transmission</th><th>Use Protection = 0 or ERP IE is not present (Operating Mode = 3)</th><th>Use Protection = 1 (Operating Mode = 1 or 3)</th></tr>
<tr><td>20 MHz transmission:</td><td>HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.</td><td>All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions.
The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.</td></tr>
<tr><td>40 MHz transmission:</td><td>HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.</td><td>All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions.
The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.</td></tr>
</table>

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.
NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).
</td></tr>
</table>

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

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	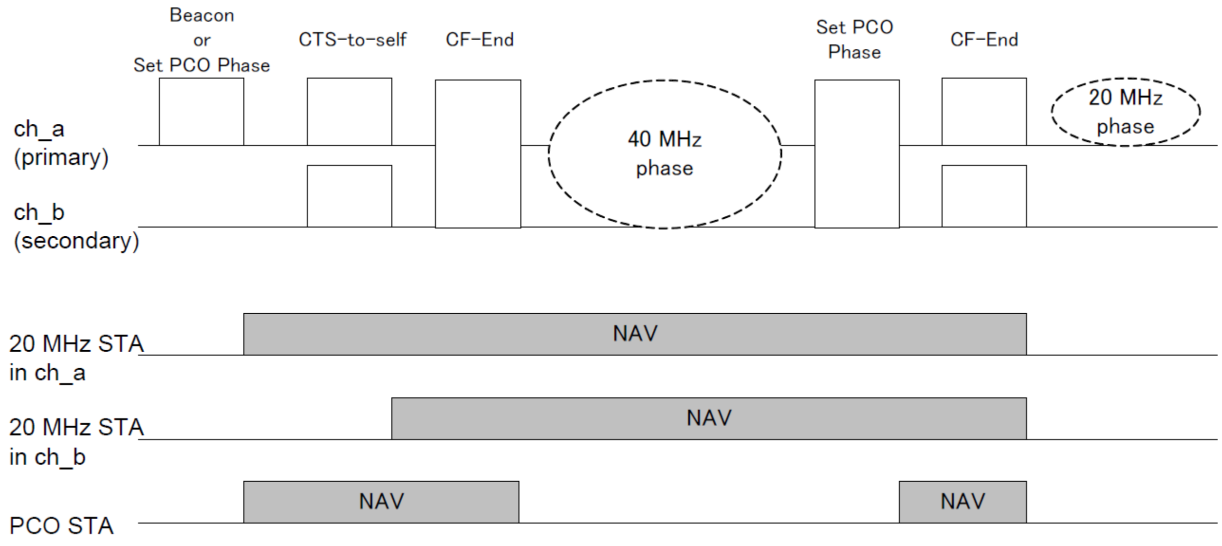 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

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	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

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	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

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	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

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	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

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	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\left\{ r(t) \exp\left(j2\pi f_c t \right) \right\}$ (20-1) where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

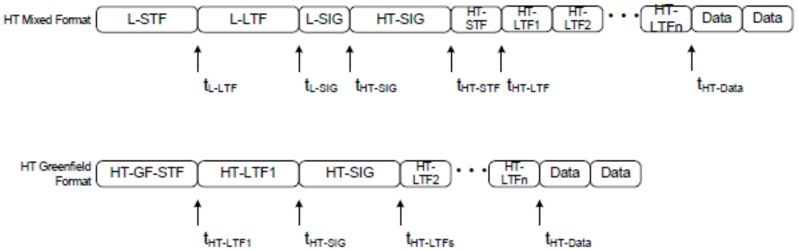

Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right)T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}\left(t - t_{HT-DATA}\right) \end{aligned} \qquad (20\text{-}2)$$

where

$$t_{L-LTF} = T_{L-STF}$$

$$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$$

$$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$$

$$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r^{(i_{TX})}_{PPDU}(t) = {} & r^{(i_{TX})}_{HT-GF-STF}(t) + r^{(i_{TX})}_{HT-LTF1}(t - t_{HT-LTF1}) \\ & + r^{(i_{TX})}_{HT-SIG}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r^{(i_{TX}, i_{LTF})}_{HT-LTF}(t - t_{HT-LTFs} - (i_{LTF} - 2) T_{HT-LTFs}) \\ & + r^{(i_{TX})}_{HT-DATA}(t - t_{HT-DATA}) \end{aligned} \qquad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r^{(i_{TX})}_{\text{Field}}(t)$, is defined via the discrete Fourier transform as

$$r^{(i_{TX})}_{\text{Field}}(t) = \frac{1}{\sqrt{N^{\text{Tone}}_{\text{Field}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X^{(i_{TX})}_k \exp(j 2\pi k \Delta_F t) \qquad (20\text{-}4)$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X^{(i_{TX})}_k$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \qquad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \qquad (20\text{-}6)$$

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	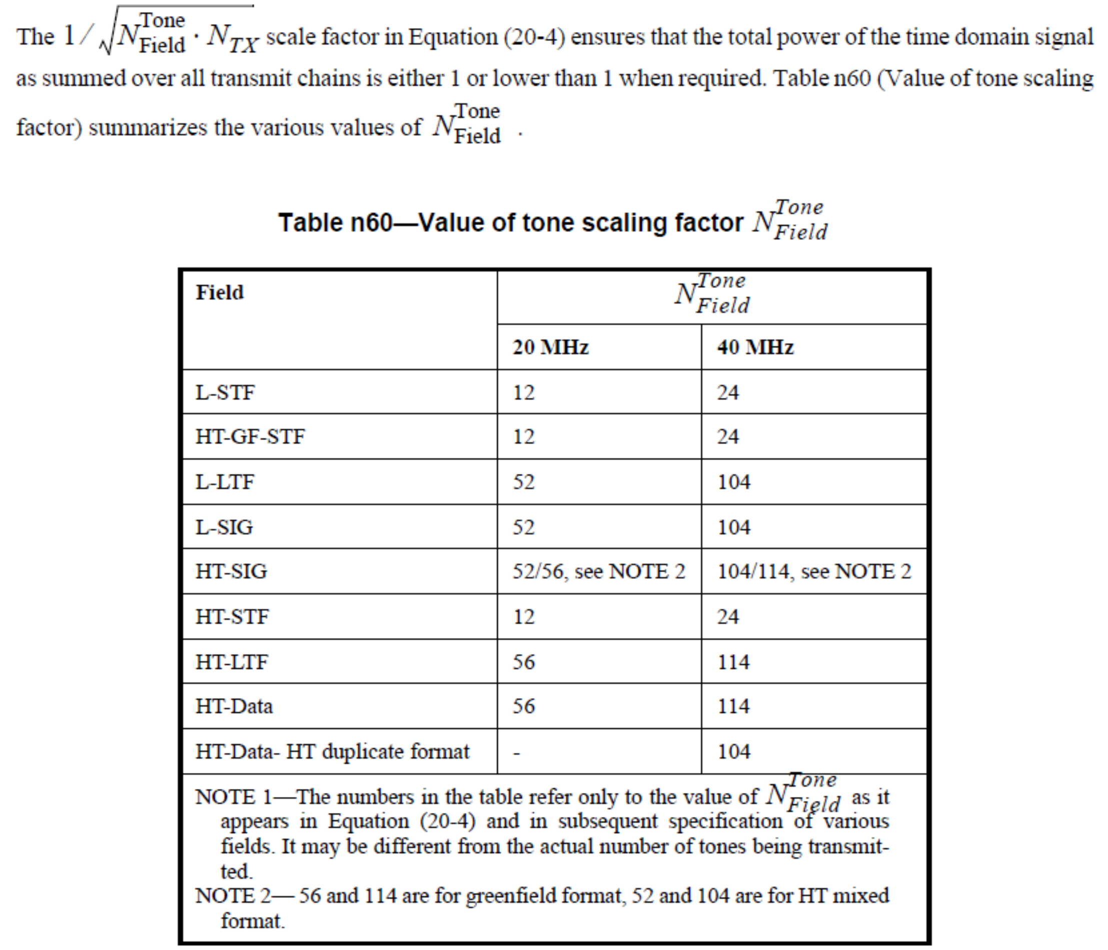 The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$. **Table n60—Value of tone scaling factor N_{Field}^{Tone}** See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65 **20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel** When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	40 MHz
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

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	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS} \cdot N^{Tone}_{HT-DATA}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P^k_{(i_{STS},n)}) \exp(j 2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T^{i_{STS}}_{CS}))$ (20-58) where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

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	See, e.g., 802.11n D2.0 § 20.3.10.10.2 **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P_{(i_{STS}, n)}^k) \Upsilon_k \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (20-59) where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

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	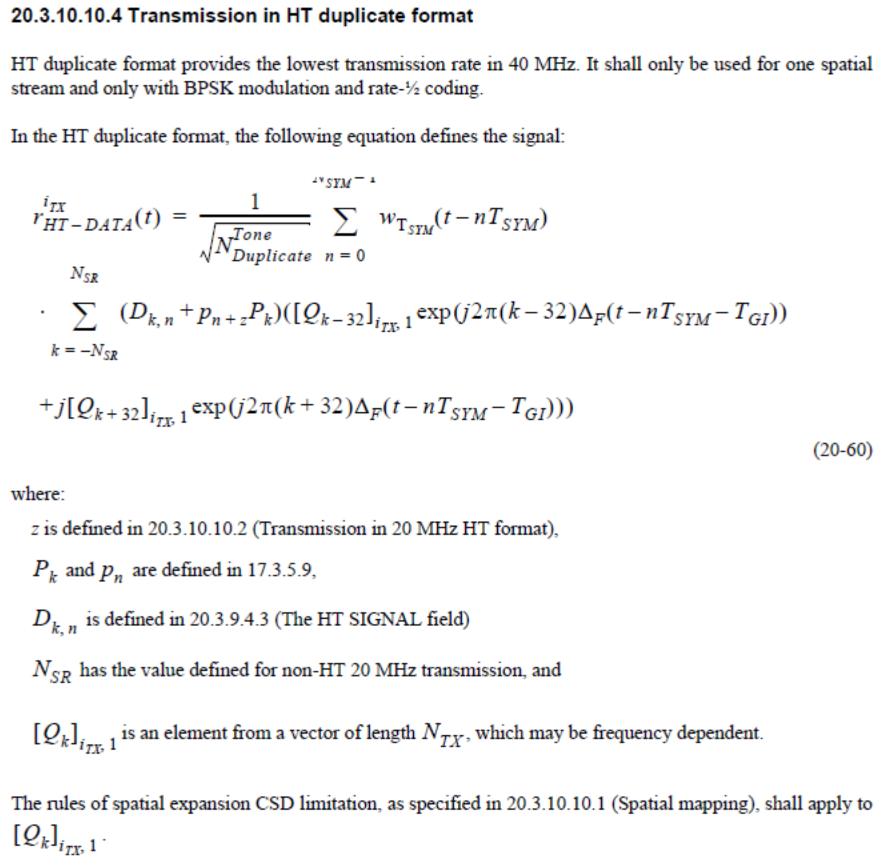 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM})$ $\cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n} + p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t - nT_{SYM} - T_{GI}))$ $+ j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t - nT_{SYM} - T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

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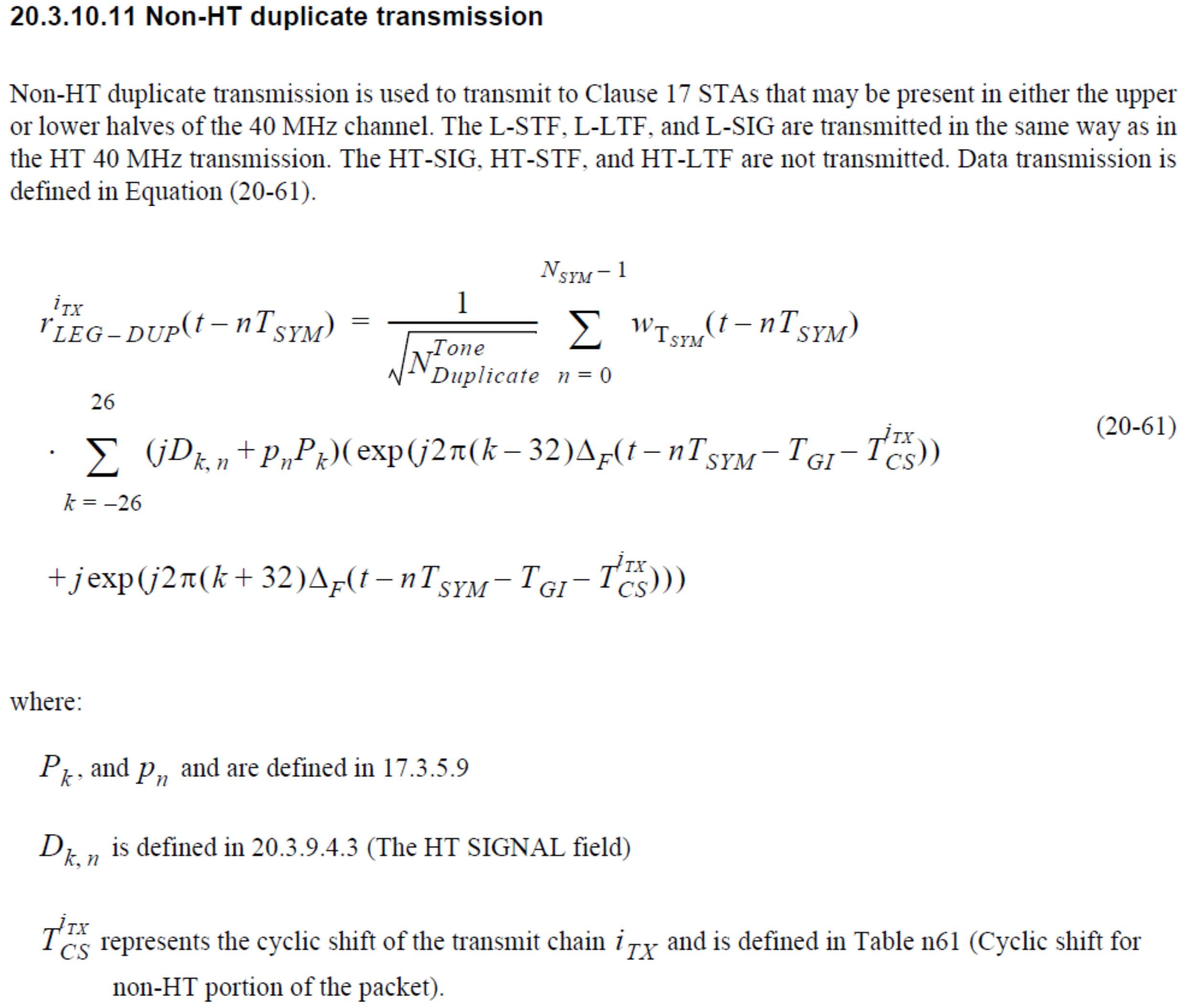
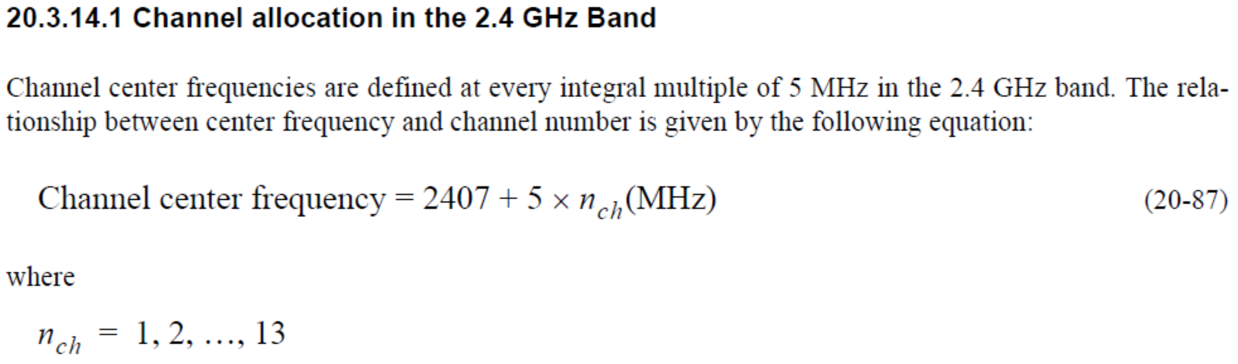
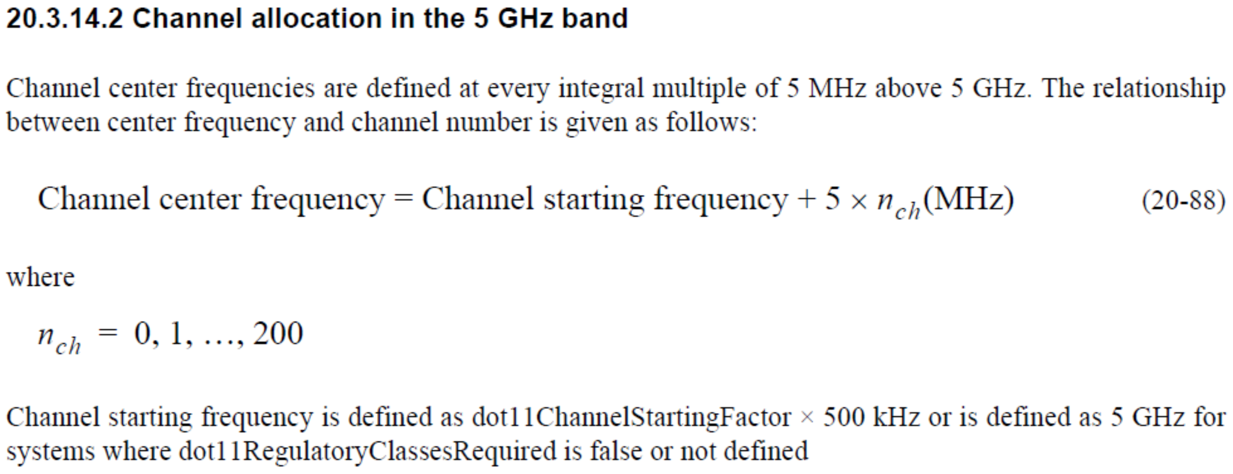
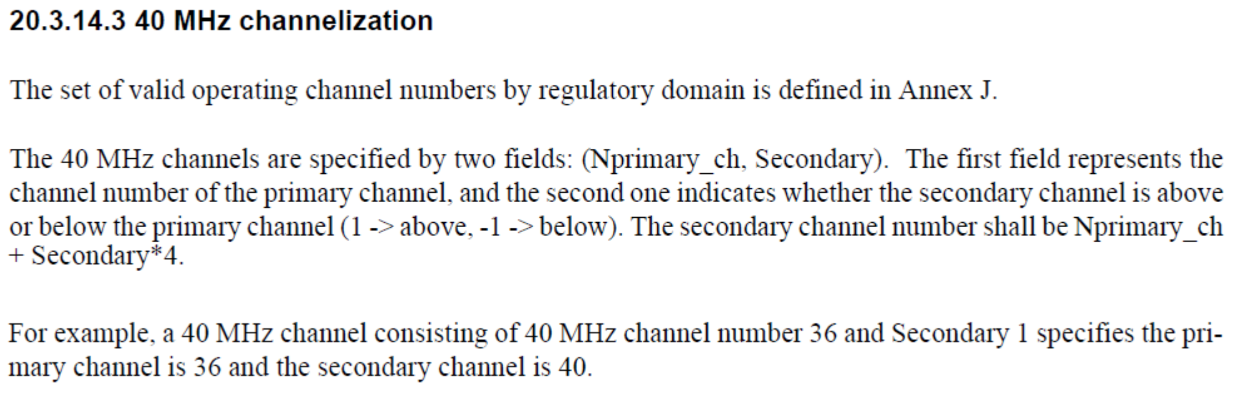
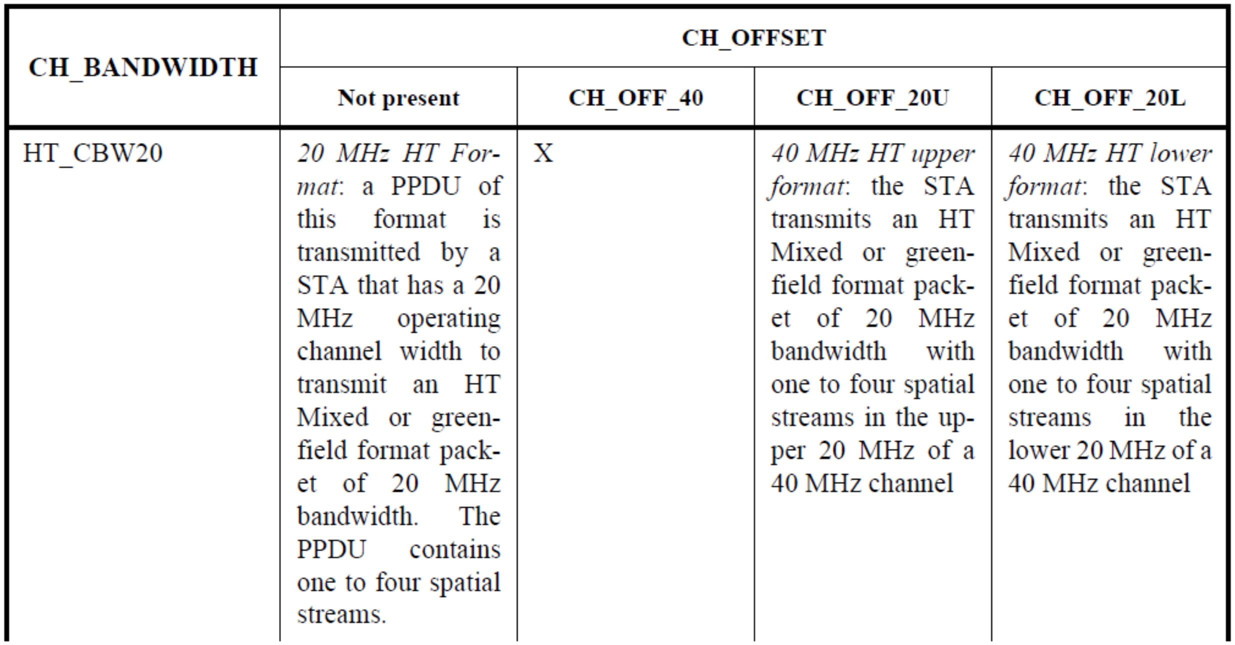
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r^{i_{TX}}_{LEG-DUP}(t-nT_{SYM}) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n}+p_n P_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T^{i_{TX}}_{CS}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz}) \qquad (20\text{-}87)$ where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz}) \qquad (20\text{-}88)$ where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

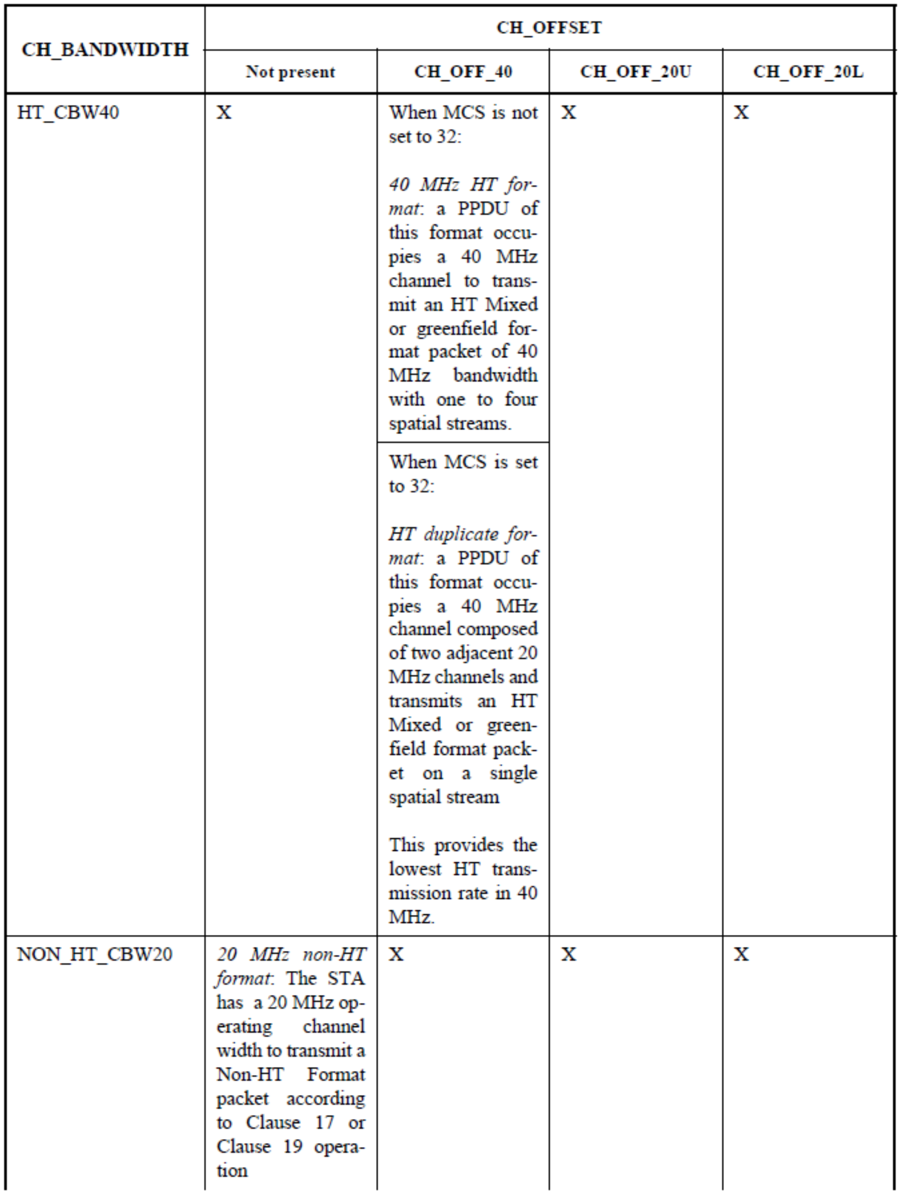
Claim 17 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.20.3

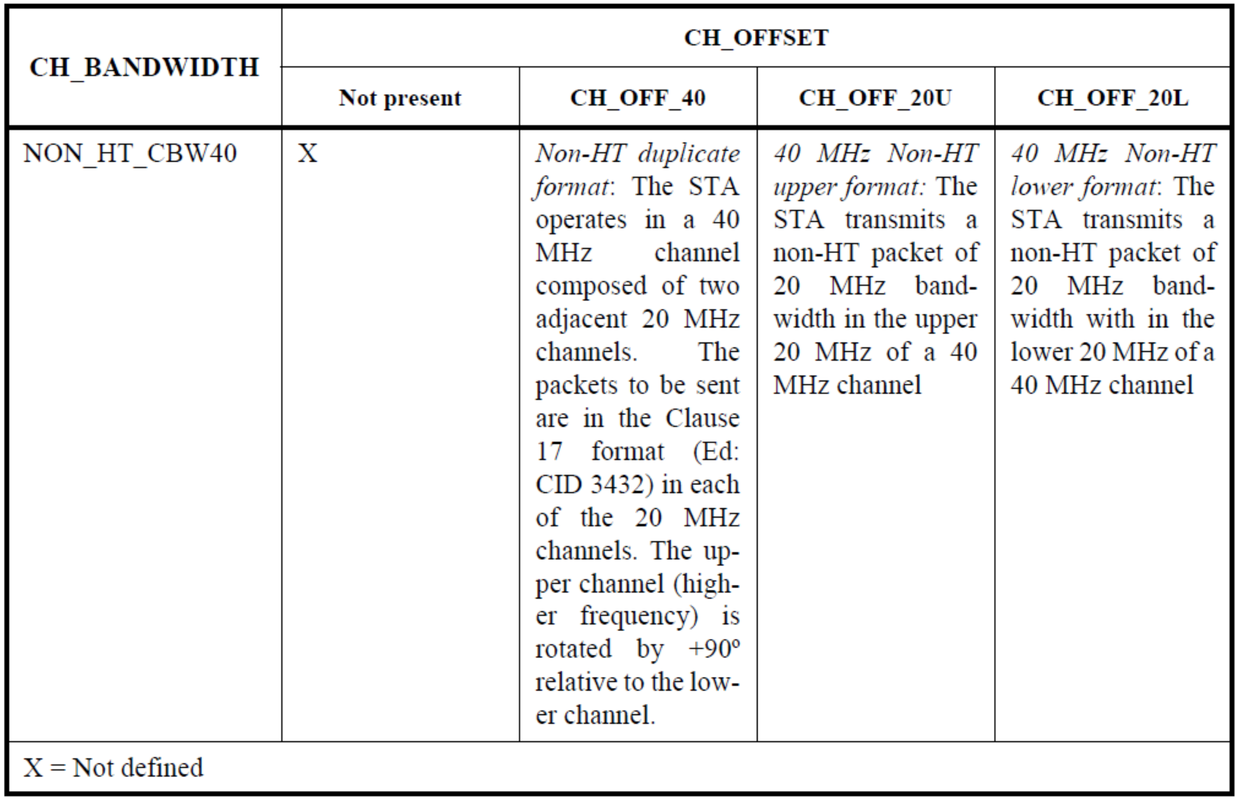
Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

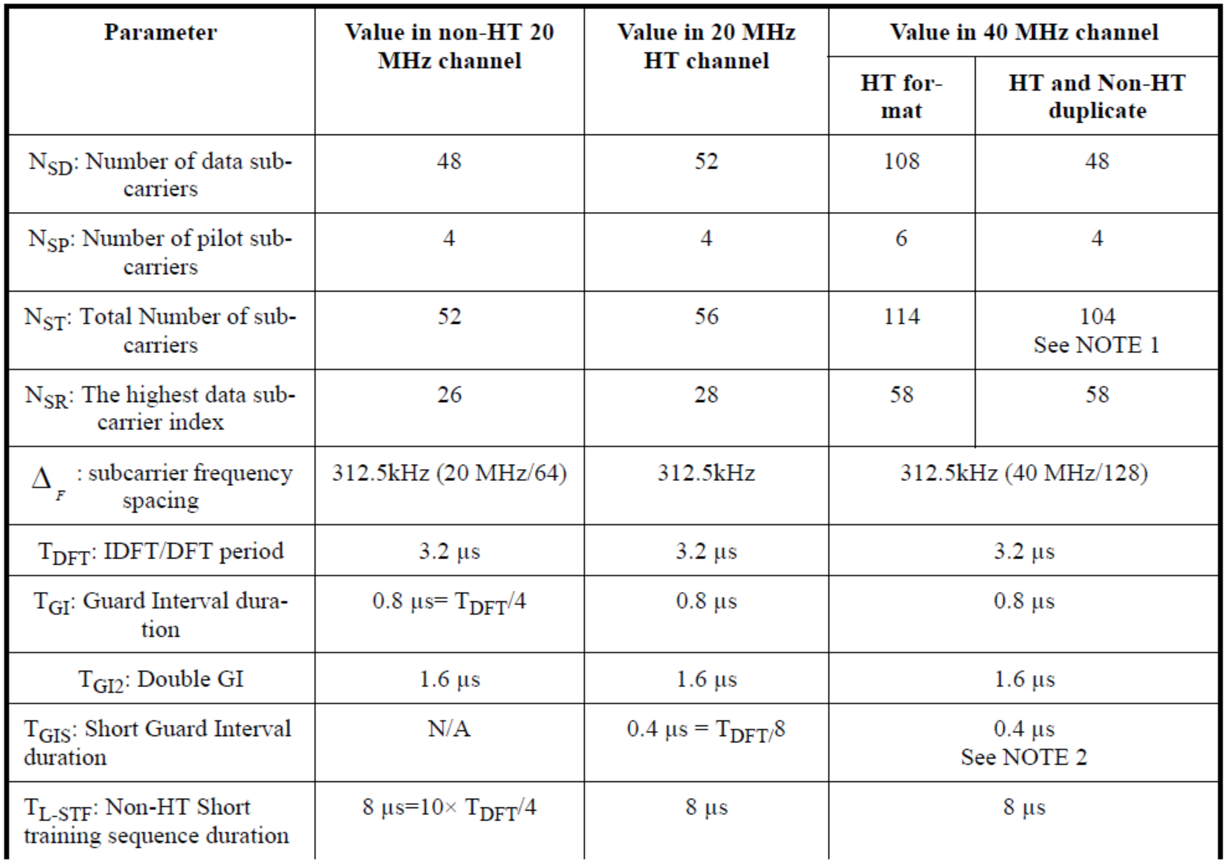


CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel

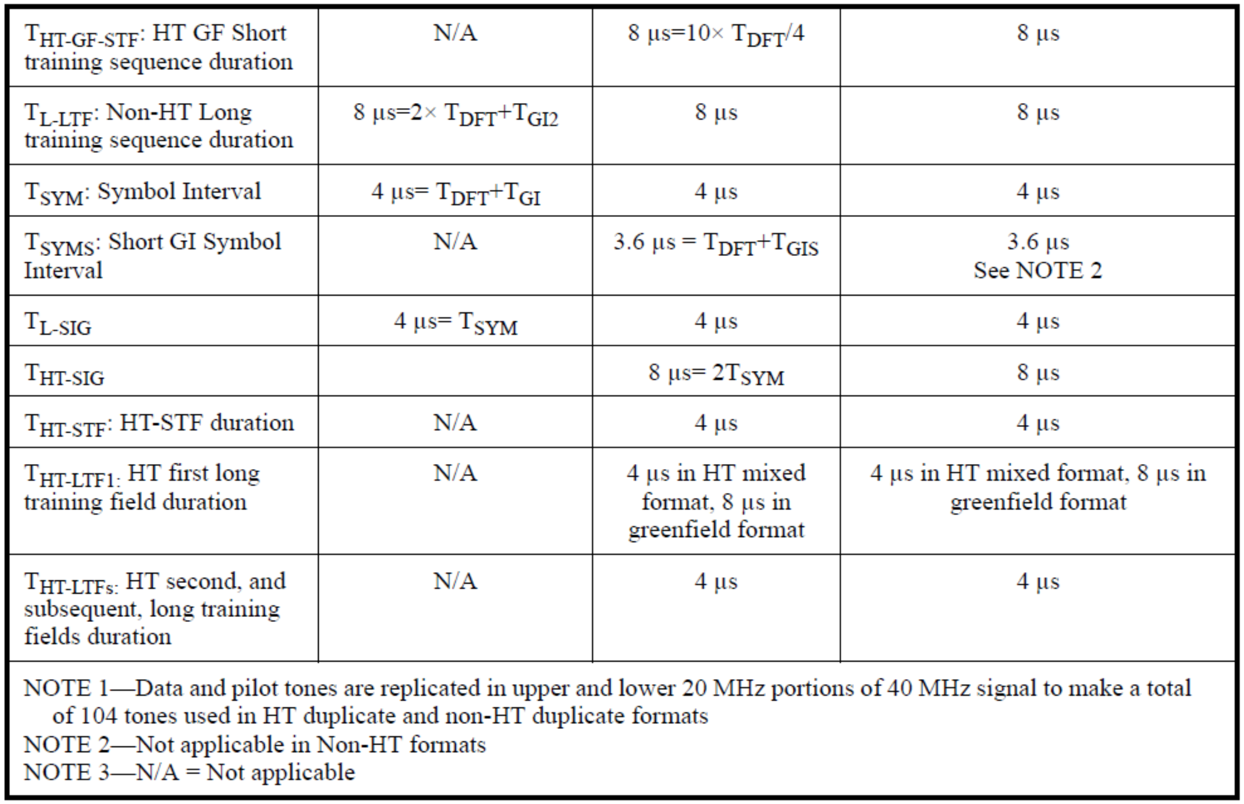


CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

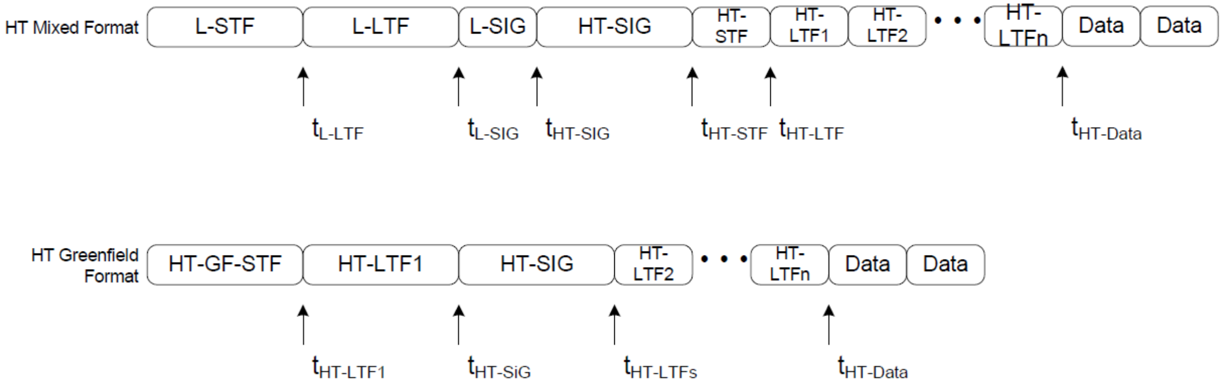
<table>
<tr><th>Claim 17 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>NON_HT_CBW40</td><td>X</td><td>*Non-HT duplicate format*: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.</td><td>*40 MHz Non-HT upper format:* The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel</td><td>*40 MHz Non-HT lower format*: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel</td></tr>
<tr><td colspan="5">X = Not defined</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n55
</td></tr>
</table>

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	Table n58—Timing related constants 

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

<table>
<tr><th>Claim 17 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><td>$T_{HT-GF-STF}$: HT GF Short training sequence duration</td><td>N/A</td><td>8 µs=10× T_{DFT}/4</td><td>8 µs</td></tr>
<tr><td>T_{L-LTF}: Non-HT Long training sequence duration</td><td>8 µs=2× T_{DFT}+T_{GI2}</td><td>8 µs</td><td>8 µs</td></tr>
<tr><td>T_{SYM}: Symbol Interval</td><td>4 µs= T_{DFT}+T_{GI}</td><td>4 µs</td><td>4 µs</td></tr>
<tr><td>T_{SYMS}: Short GI Symbol Interval</td><td>N/A</td><td>3.6 µs = T_{DFT}+T_{GIS}</td><td>3.6 µs
See NOTE 2</td></tr>
<tr><td>T_{L-SIG}</td><td>4 µs= T_{SYM}</td><td>4 µs</td><td>4 µs</td></tr>
<tr><td>T_{HT-SIG}</td><td></td><td>8 µs= 2T_{SYM}</td><td>8 µs</td></tr>
<tr><td>T_{HT-STF}: HT-STF duration</td><td>N/A</td><td>4 µs</td><td>4 µs</td></tr>
<tr><td>$T_{HT-LTF1:}$ HT first long training field duration</td><td>N/A</td><td>4 µs in HT mixed format, 8 µs in greenfield format</td><td>4 µs in HT mixed format, 8 µs in greenfield format</td></tr>
<tr><td>$T_{HT-LTFs:}$ HT second, and subsequent, long training fields duration</td><td>N/A</td><td>4 µs</td><td>4 µs</td></tr>
<tr><td colspan="4">NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable</td></tr>
</table>

See, e.g., 802.11n D2.0 Table n58
</td></tr>
</table>

Claim 17 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.
[17.6] a second up-converter circuit having a first input coupled to receive the second analog signal and a second input coupled to receive a second modulation signal having a second RF frequency, wherein the second	802.11n D2.0 discloses "a second up-converter circuit having a first input coupled to receive the second analog signal and a second input coupled to receive a second modulation signal having a second RF frequency, wherein the second up-converter outputs a second up-converted analog signal comprising a second up-converted frequency range from the second RF frequency minus one-half the second frequency range to the second RF frequency plus one-half the second frequency range, and wherein frequency difference between the first RF frequency and the second RF frequency is greater than the sum of one-half the first frequency range and one-half the second frequency range." See, e.g.:

Claim 17 of the '802 Patent	Prior Art Reference – 802.11n D2.0
up-converter outputs a second up-converted analog signal comprising a second up-converted frequency range from the second RF frequency minus one-half the second frequency range to the second RF frequency plus one-half the second frequency range, and wherein frequency difference between the first RF frequency and the second RF frequency is greater than the sum of one-half the first frequency range and one-half the second frequency range; and	**high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19 **non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0

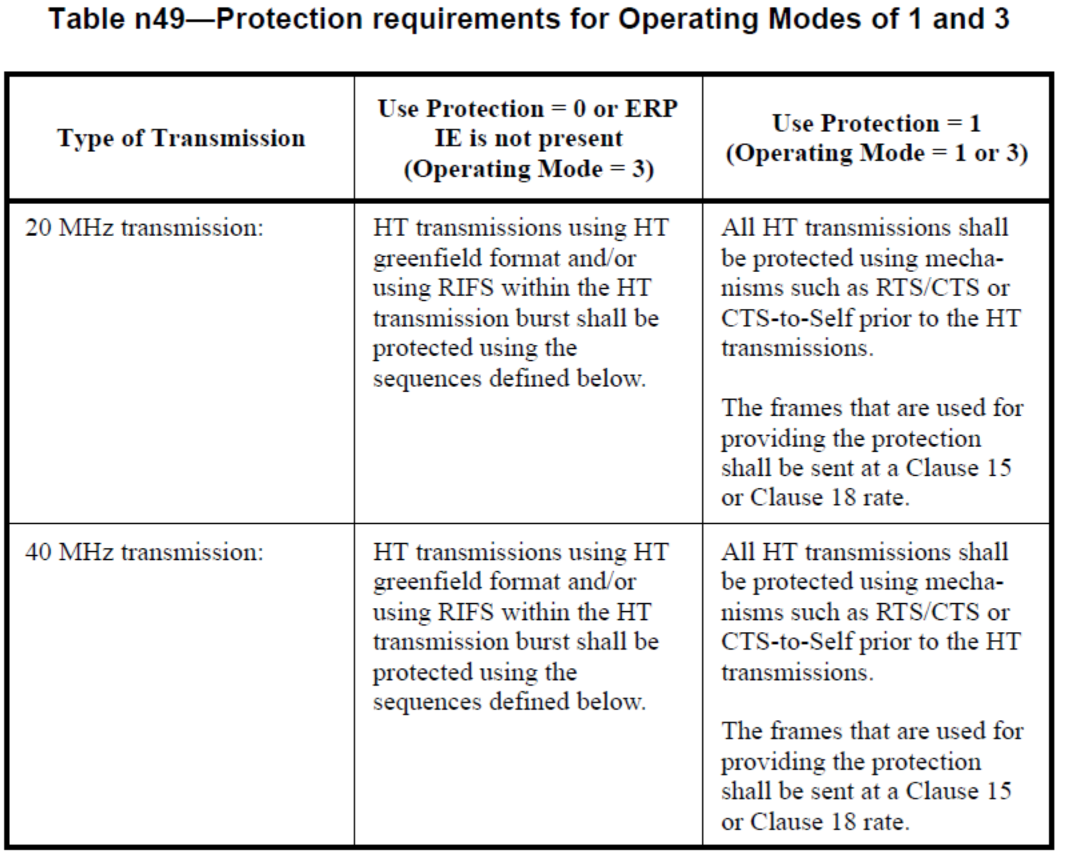


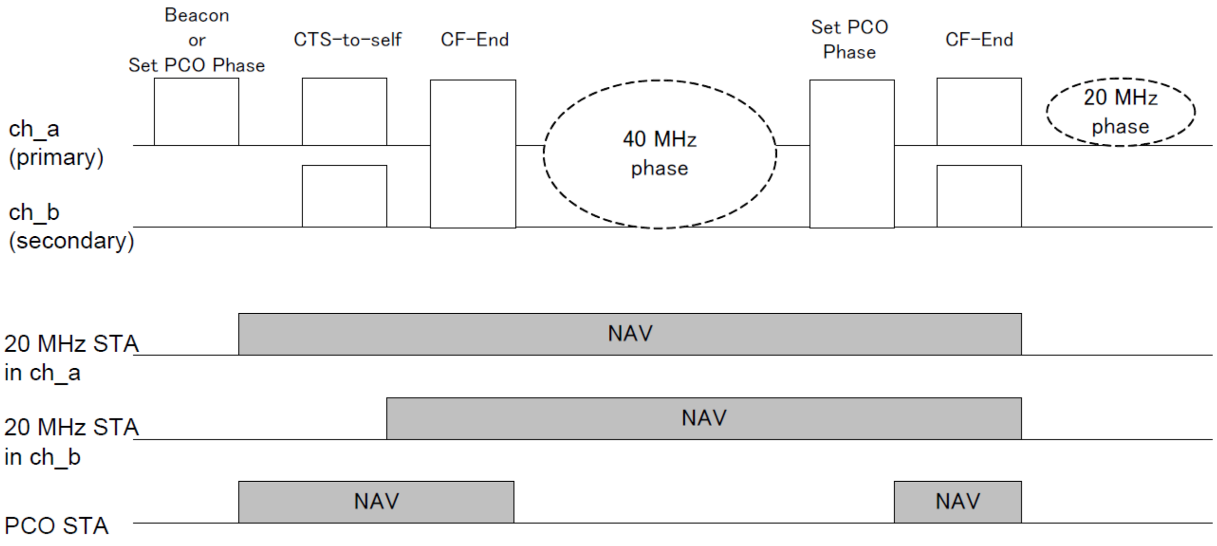
Table n49—Protection requirements for Operating Modes of 1 and 3

Type of Transmission	Use Protection = 0 or ERP IE is not present (Operating Mode = 3)	Use Protection = 1 (Operating Mode = 1 or 3)
20 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.
40 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.
NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).

Claim 17 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

<table>
<tr><th>Claim 17 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>



A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU.

During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel.

During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS.

A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS.

The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

</td></tr>
</table>

Claim 17 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format*: packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format*: packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format*: HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

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	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

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	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

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	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t \right) \right\}$ (20-1) where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

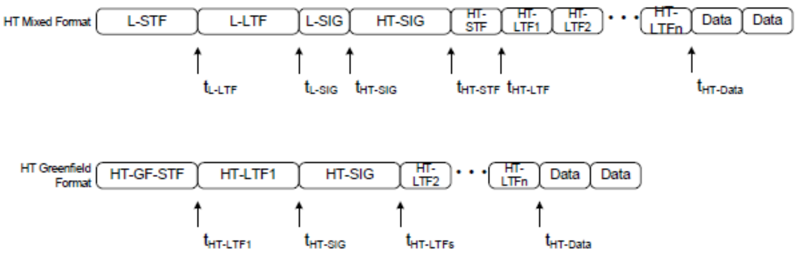

Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$
\begin{aligned}
r_{PPDU}^{(i_{TX})}(t) \quad = \quad & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\
& + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\
& + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\
& + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\
& + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right)T_{HT-LTFs}\right) \\
& + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA})
\end{aligned}
\qquad (20\text{-}2)
$$

where

$t_{L-LTF} = T_{L-STF}$

$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$

$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$

$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1}) \\ & + r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2) T_{HT-LTFs}) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \qquad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\text{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\text{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j 2\pi k \Delta_F t) \qquad (20\text{-}4)$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \qquad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \qquad (20\text{-}6)$$

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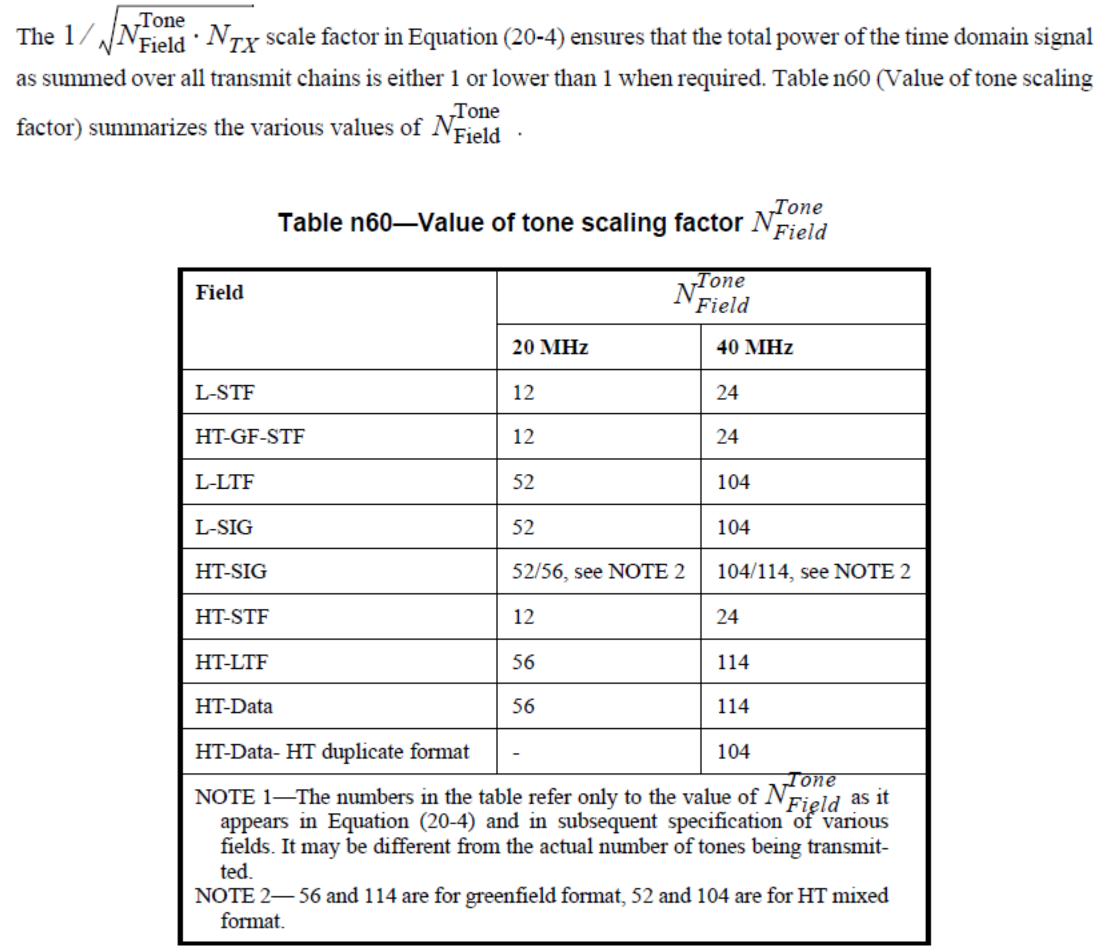

The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	40 MHz
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

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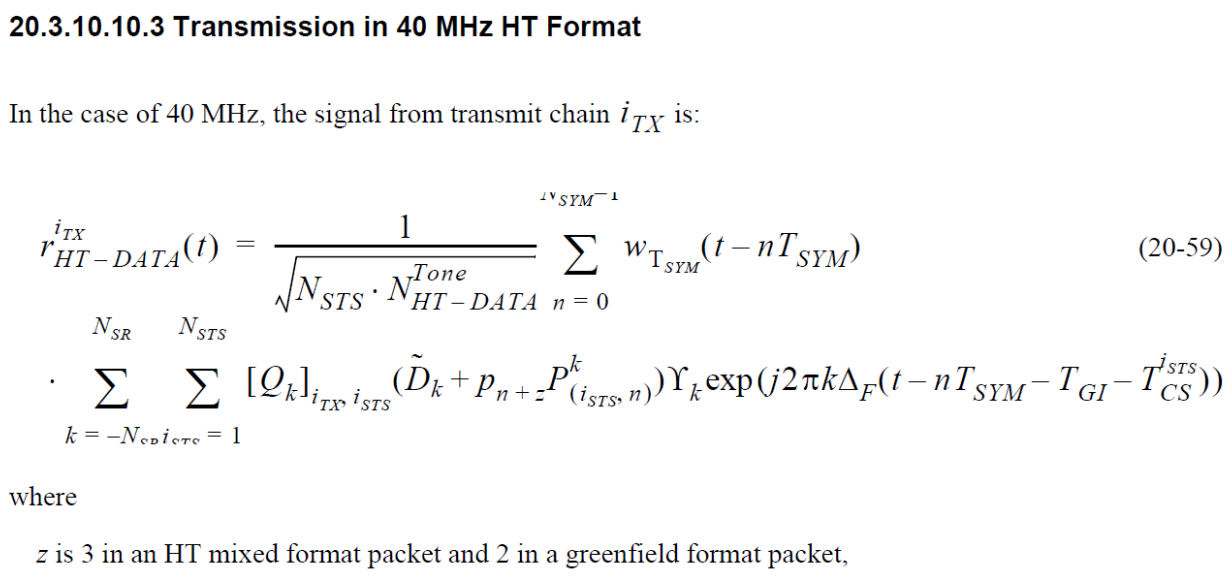
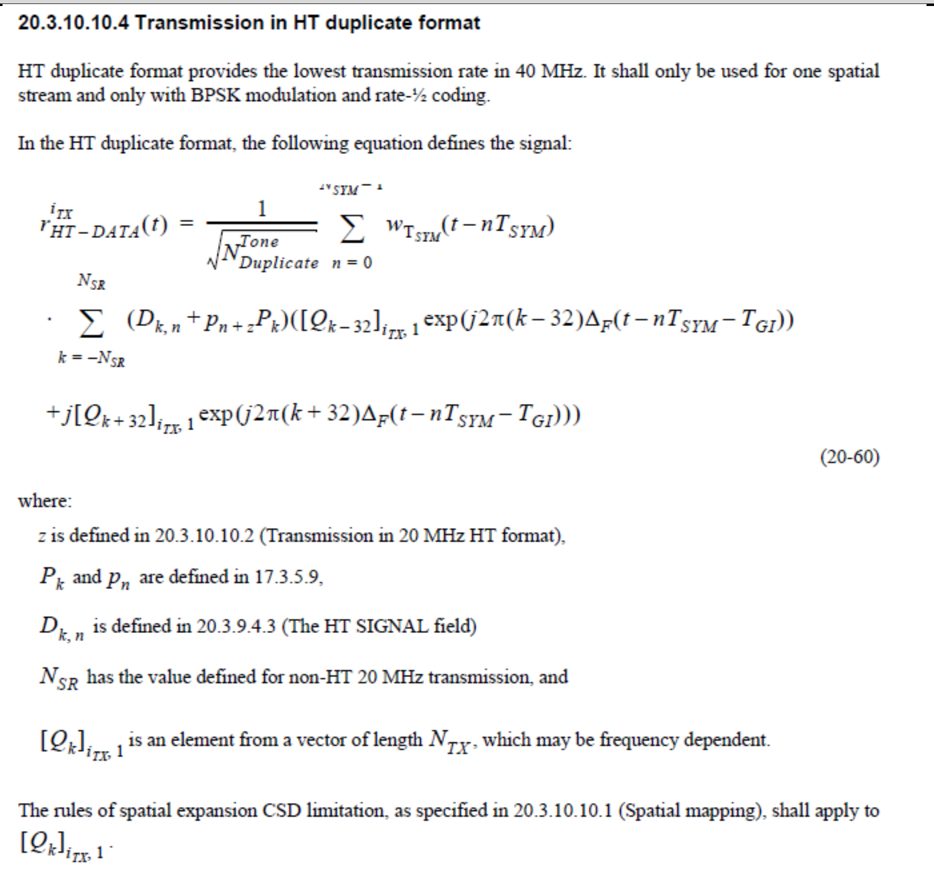
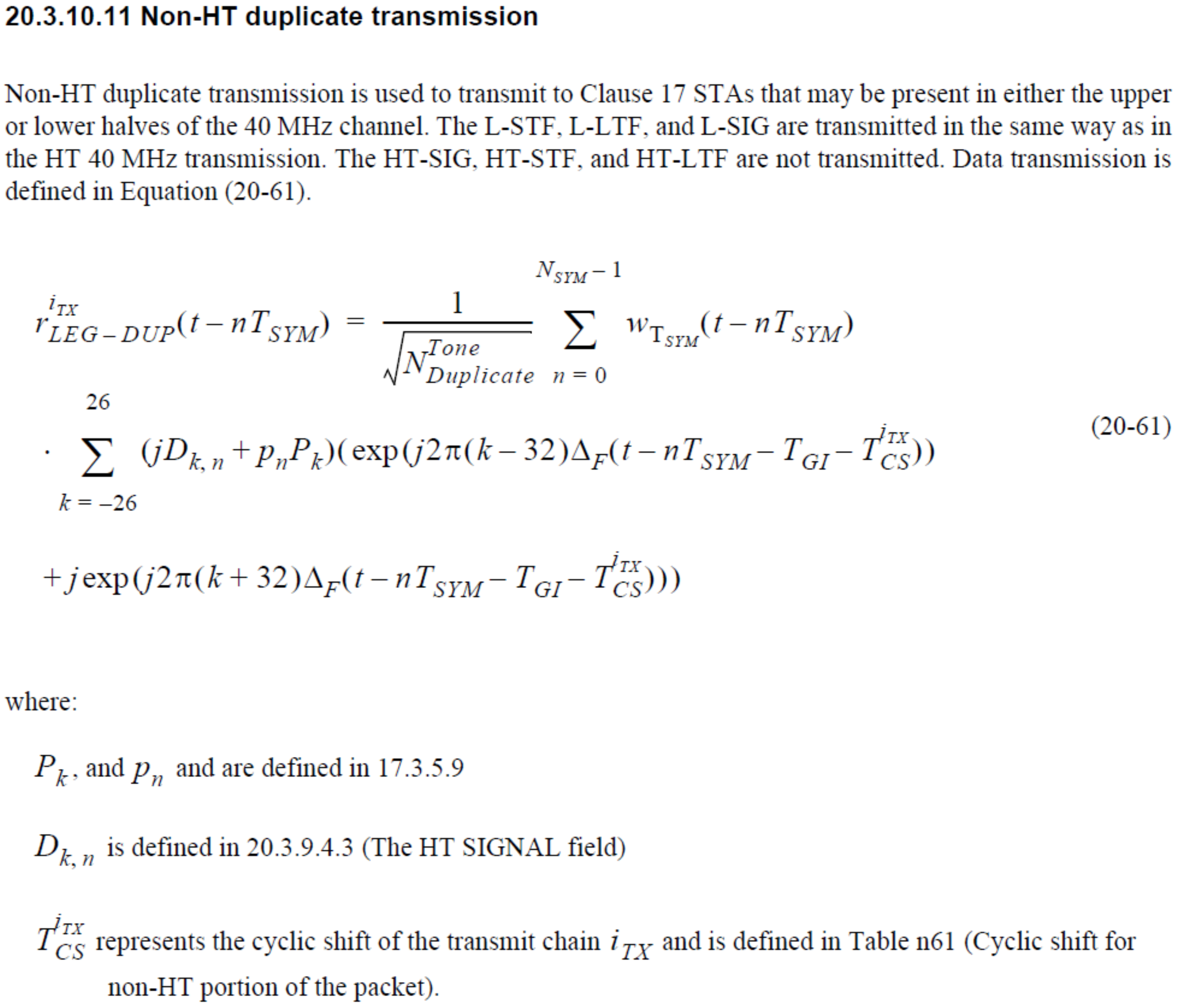
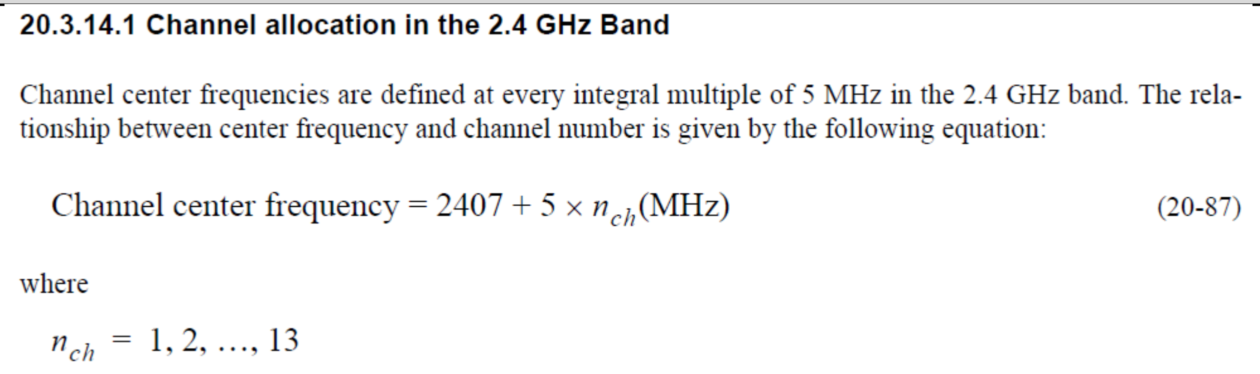
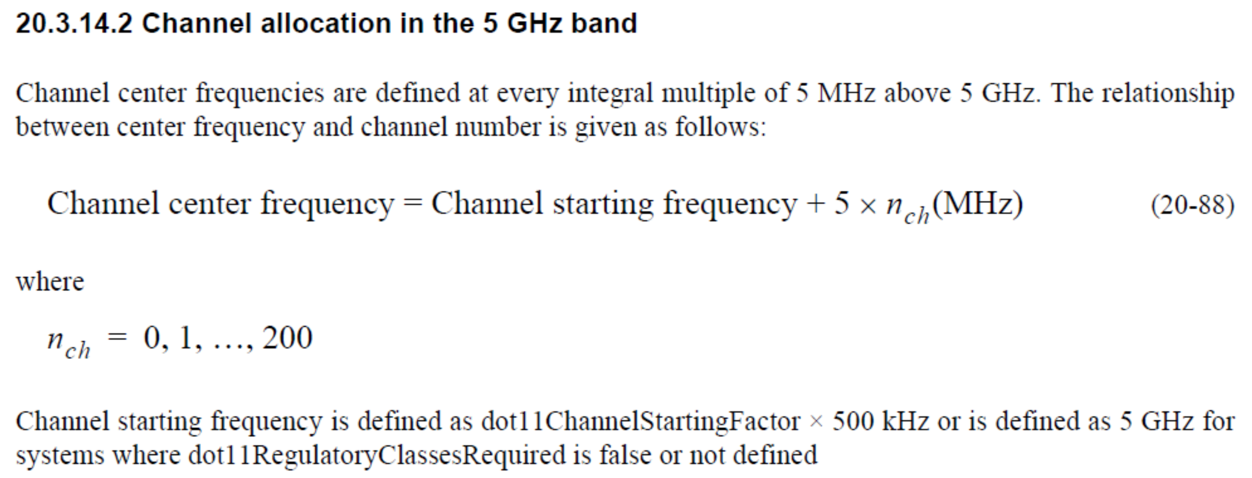
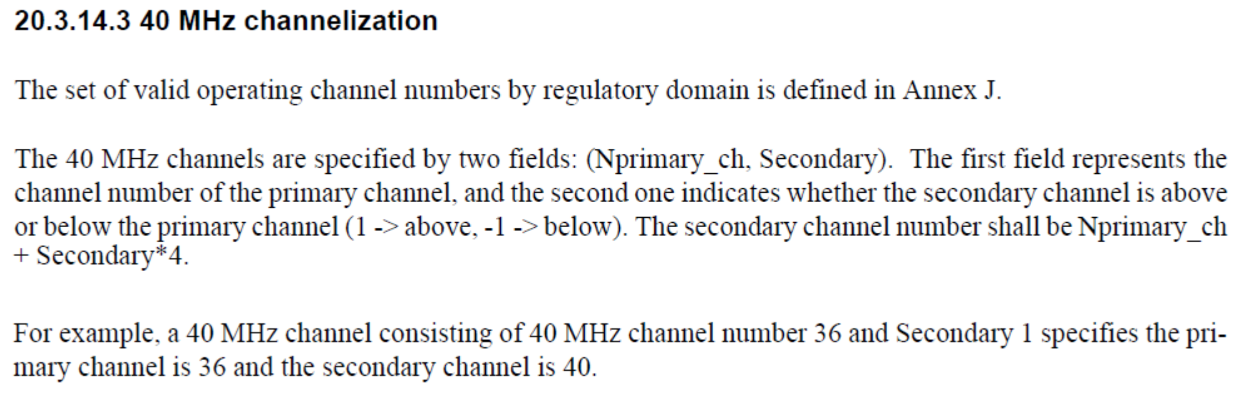
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS} \cdot N^{Tone}_{HT-DATA}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM})$ (20-58) $\cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX},i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P^k_{(i_{STS},n)}) \exp(j 2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T^{i_{STS}}_{CS}))$ where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

Claim 17 of the '802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P^k_{(i_{STS}, n)}) \Upsilon_k \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (20-59) where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n}+p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI})) + j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

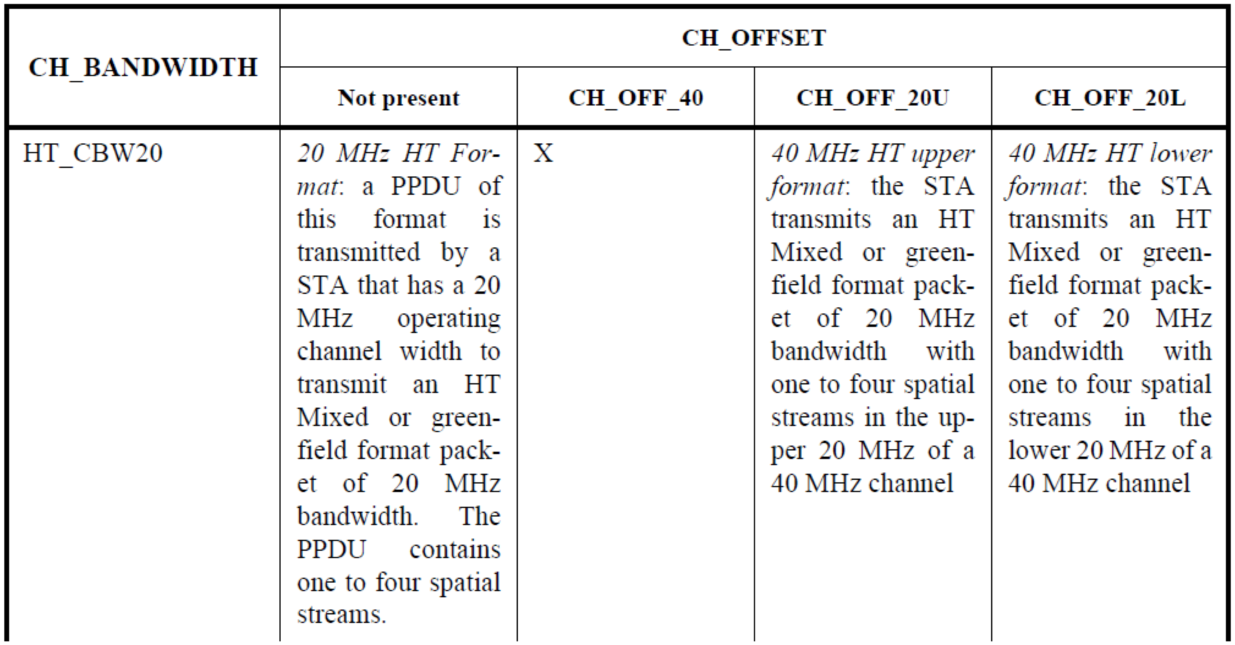
Claim 17 of the '802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r_{LEG-DUP}^{i_{TX}}(t-nT_{SYM}) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n}+p_n P_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{TX}})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{TX}})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T_{CS}^{i_{TX}}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz})$ (20-87) where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz})$ (20-88) where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

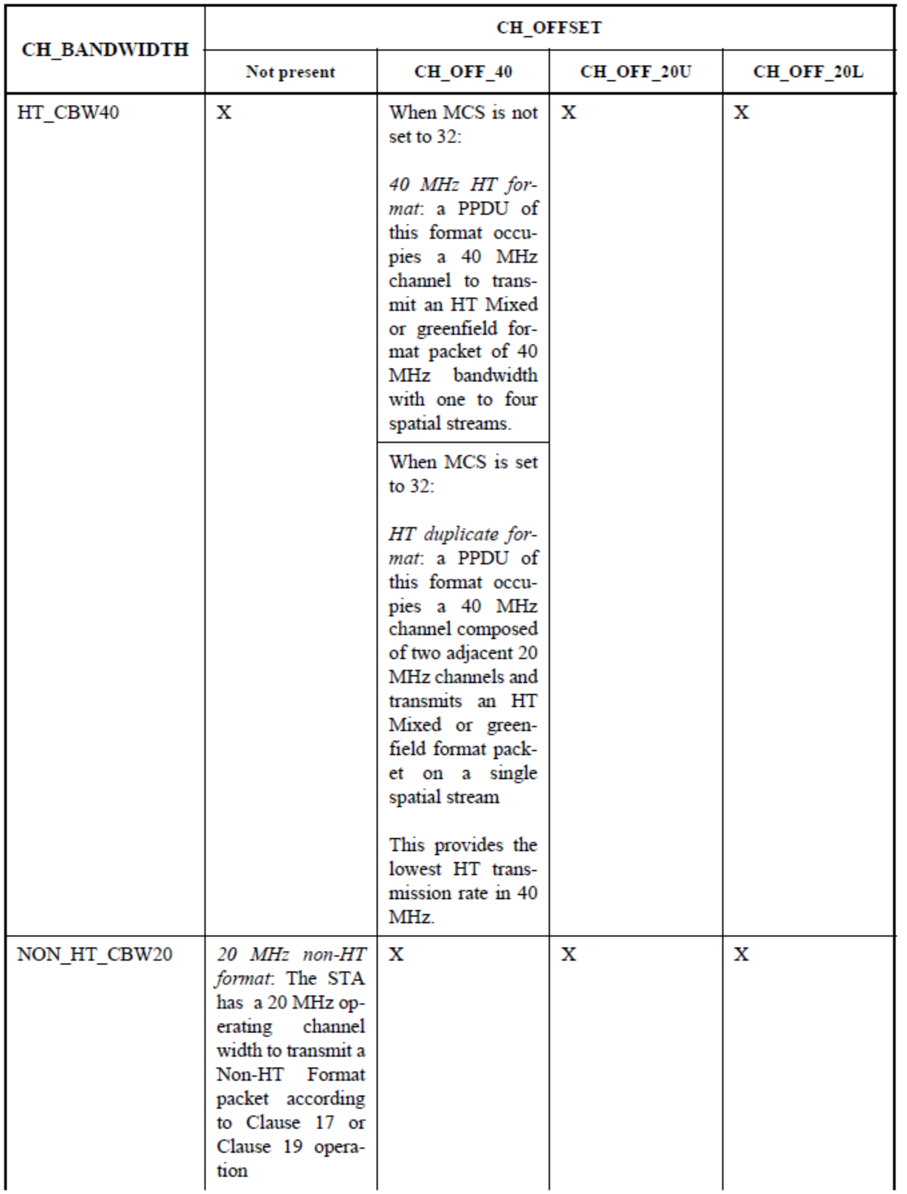
Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

Claim 17 of the '802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.20.3

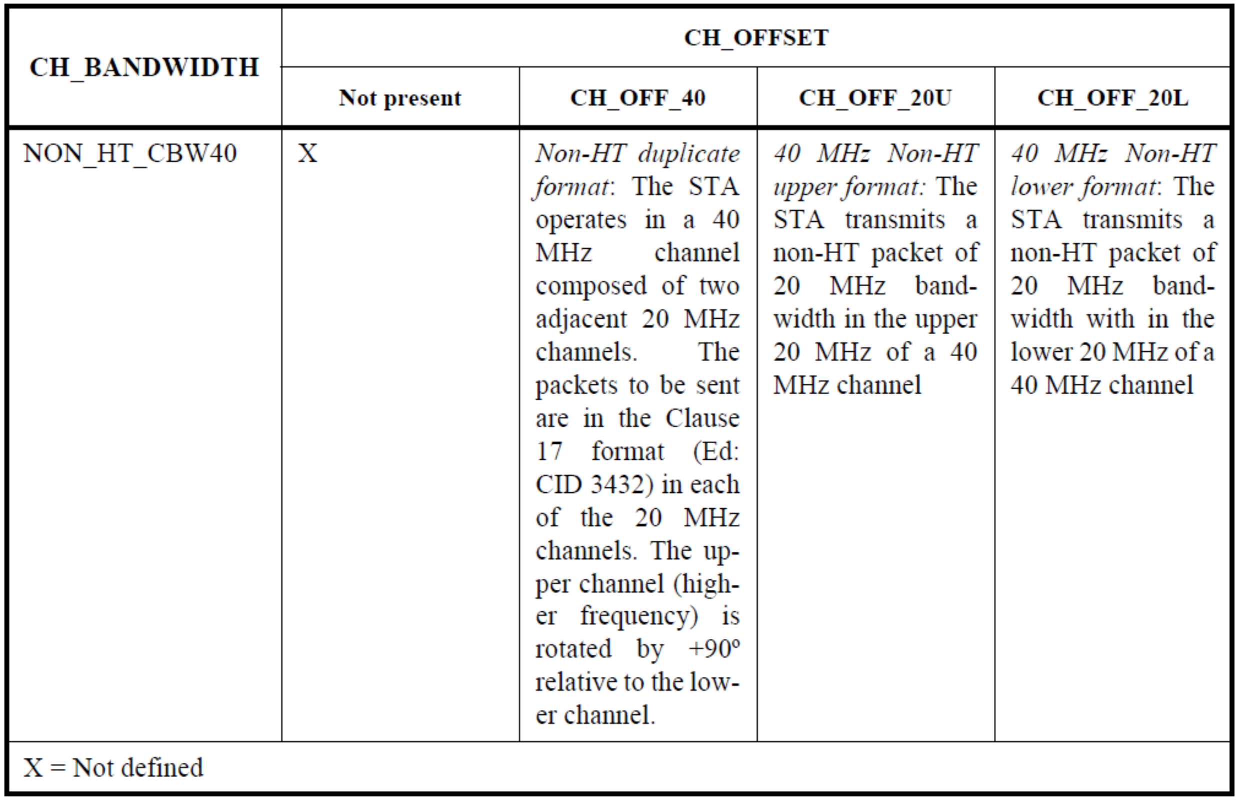
Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

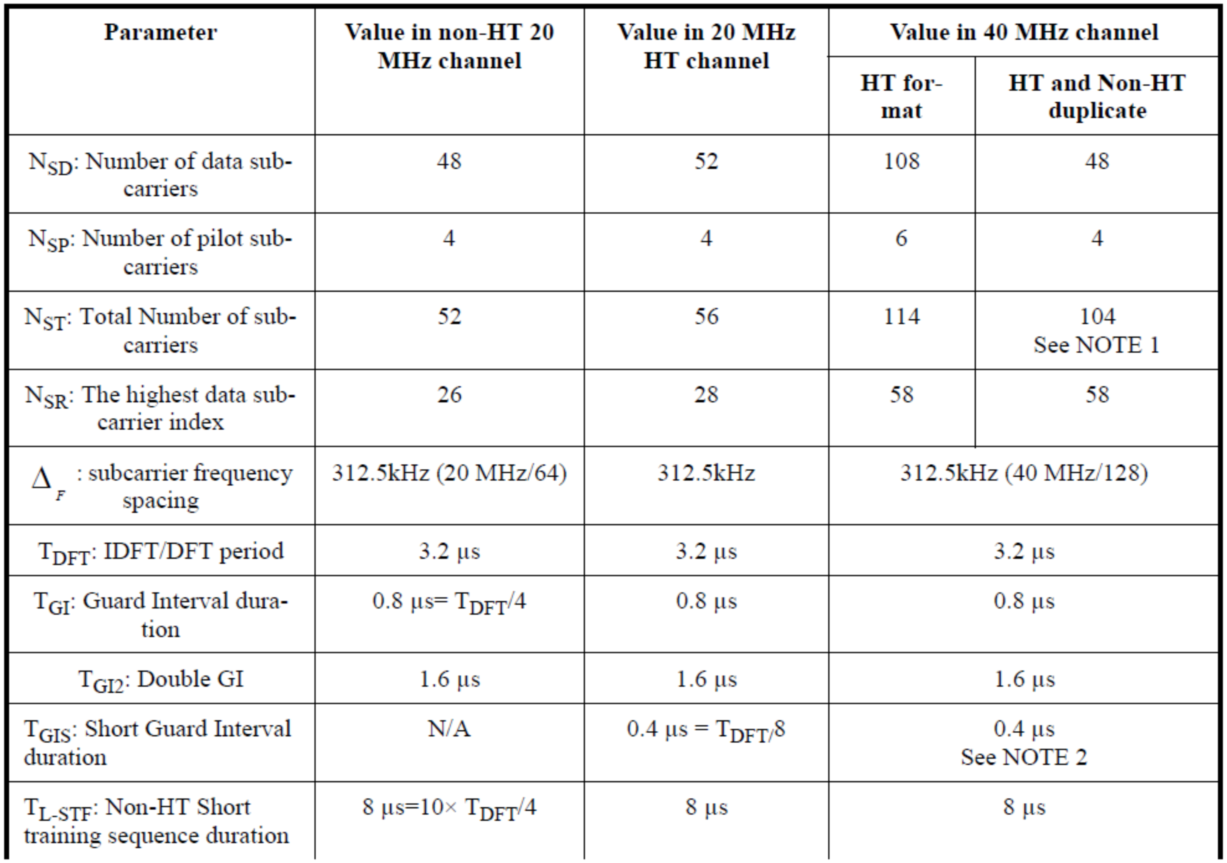


CH_BANDWIDTH	**CH_OFFSET**			
	Not present	**CH_OFF_40**	**CH_OFF_20U**	**CH_OFF_20L**
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel



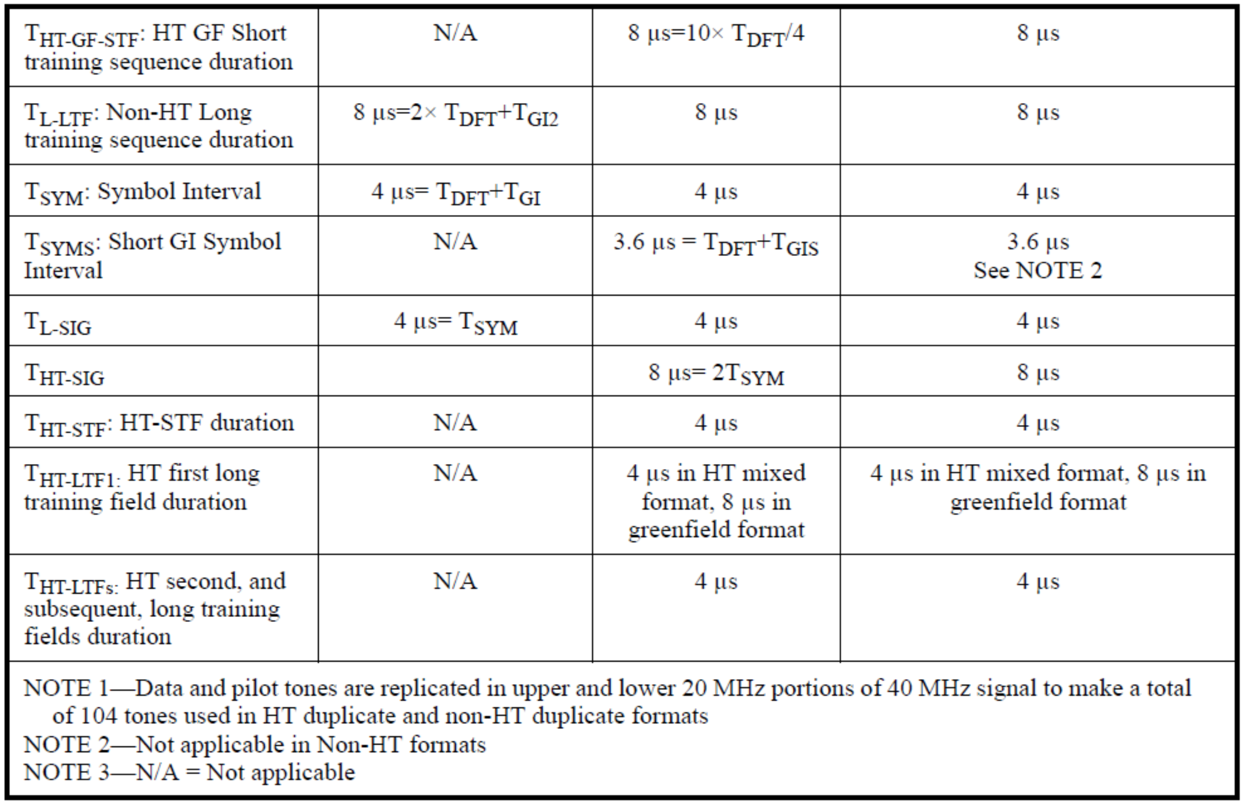
CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

<table>
<tr><th>Claim 17 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>NON_HT_CBW40</td><td>X</td><td>Non-HT duplicate format: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.</td><td>40 MHz Non-HT upper format: The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel</td><td>40 MHz Non-HT lower format: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel</td></tr>
<tr><td colspan="5">X = Not defined</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n55
</td></tr>
</table>

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	Table n58—Timing related constants 

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

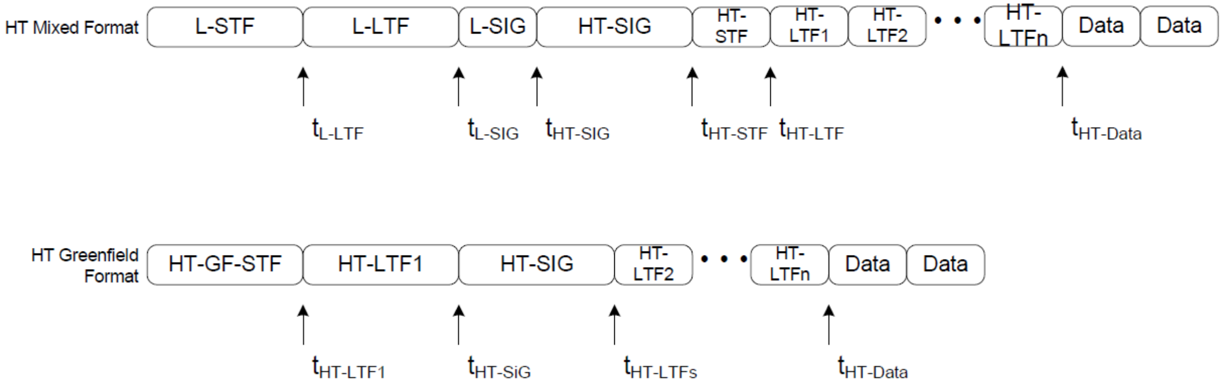
Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0



$T_{HT\text{-}GF\text{-}STF}$: HT GF Short training sequence duration	N/A	8 µs=10× T_{DFT}/4	8 µs
$T_{L\text{-}LTF}$: Non-HT Long training sequence duration	8 µs=2× $T_{DFT}+T_{GI2}$	8 µs	8 µs
T_{SYM}: Symbol Interval	4 µs= $T_{DFT}+T_{GI}$	4 µs	4 µs
T_{SYMS}: Short GI Symbol Interval	N/A	3.6 µs = $T_{DFT}+T_{GIS}$	3.6 µs See NOTE 2
$T_{L\text{-}SIG}$	4 µs= T_{SYM}	4 µs	4 µs
$T_{HT\text{-}SIG}$		8 µs= 2T_{SYM}	8 µs
$T_{HT\text{-}STF}$: HT-STF duration	N/A	4 µs	4 µs
$T_{HT\text{-}LTF1}$: HT first long training field duration	N/A	4 µs in HT mixed format, 8 µs in greenfield format	4 µs in HT mixed format, 8 µs in greenfield format
$T_{HT\text{-}LTFs}$: HT second, and subsequent, long training fields duration	N/A	4 µs	4 µs

NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable

See, e.g., 802.11n D2.0 Table n58

Claim 17 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.
[17.7] a power amplifier coupled to receive the first and second up-converted analog signals, wherein the bandwidth of the power amplifier is greater than the difference between a lowest frequency in the first up-	802.11n D2.0 discloses “a power amplifier coupled to receive the first and second up-converted analog signals, wherein the bandwidth of the power amplifier is greater than the difference between a lowest frequency in the first up-converted frequency range and a highest frequency in the second up-converted frequency range.” See, e.g.: **high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19

Claim 17 of the '802 Patent	Prior Art Reference – 802.11n D2.0
converted frequency range and a highest frequency in the second up-converted frequency range.	**non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0

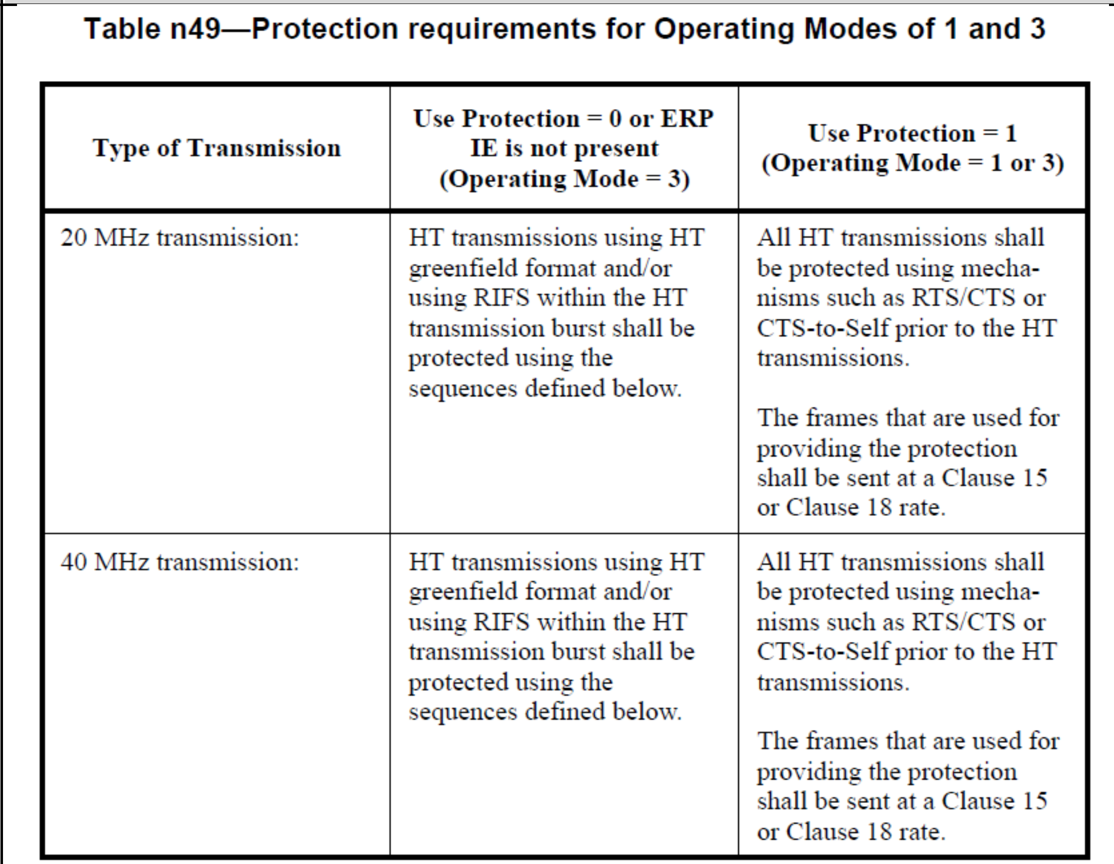


Table n49—Protection requirements for Operating Modes of 1 and 3

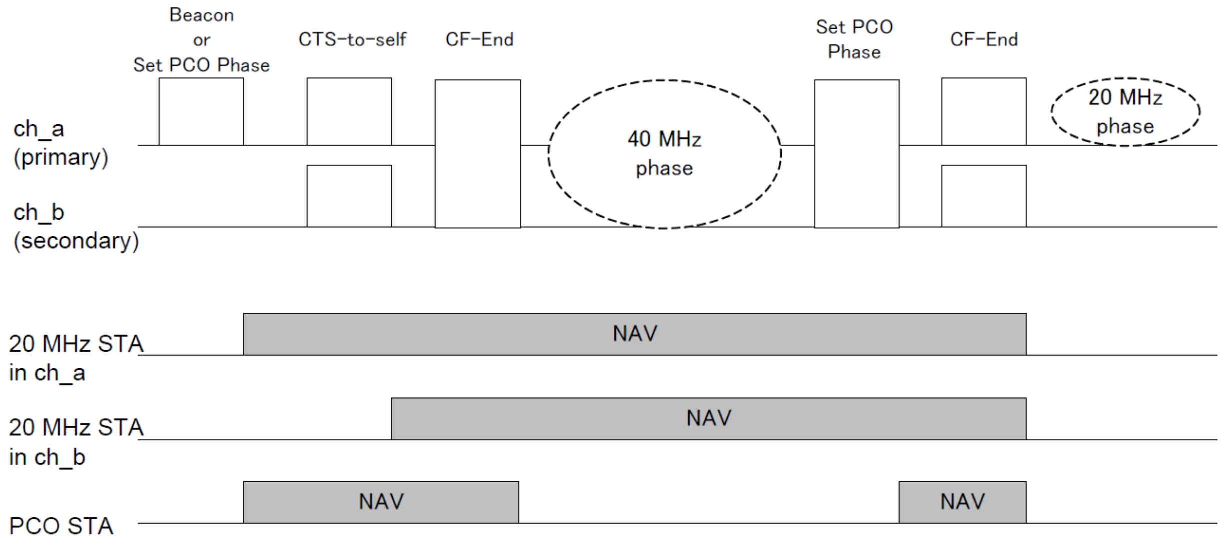
Type of Transmission	Use Protection = 0 or ERP IE is not present (Operating Mode = 3)	Use Protection = 1 (Operating Mode = 1 or 3)
20 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.
40 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:

a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.

NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format*: packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format*: packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format*: HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

Claim 17 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

Claim 17 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t \right) \right\}$ (20-1) where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

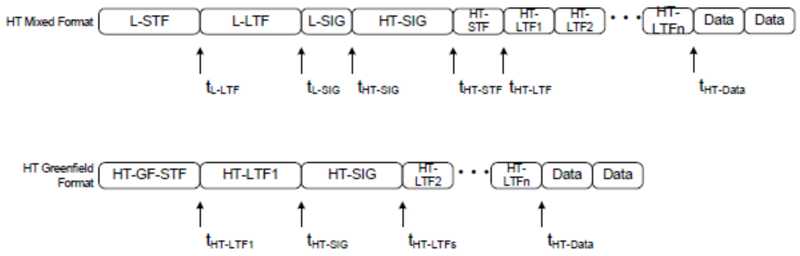


Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right) T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}\left(t - t_{HT-DATA}\right) \end{aligned} \tag{20-2}$$

where

$t_{L-LTF} = T_{L-STF}$

$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$

$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$

$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1}) \\ & + r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2)T_{HT-LTFs}) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \quad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\text{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\text{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j 2\pi k \Delta_F t) \quad (20\text{-}4)$$

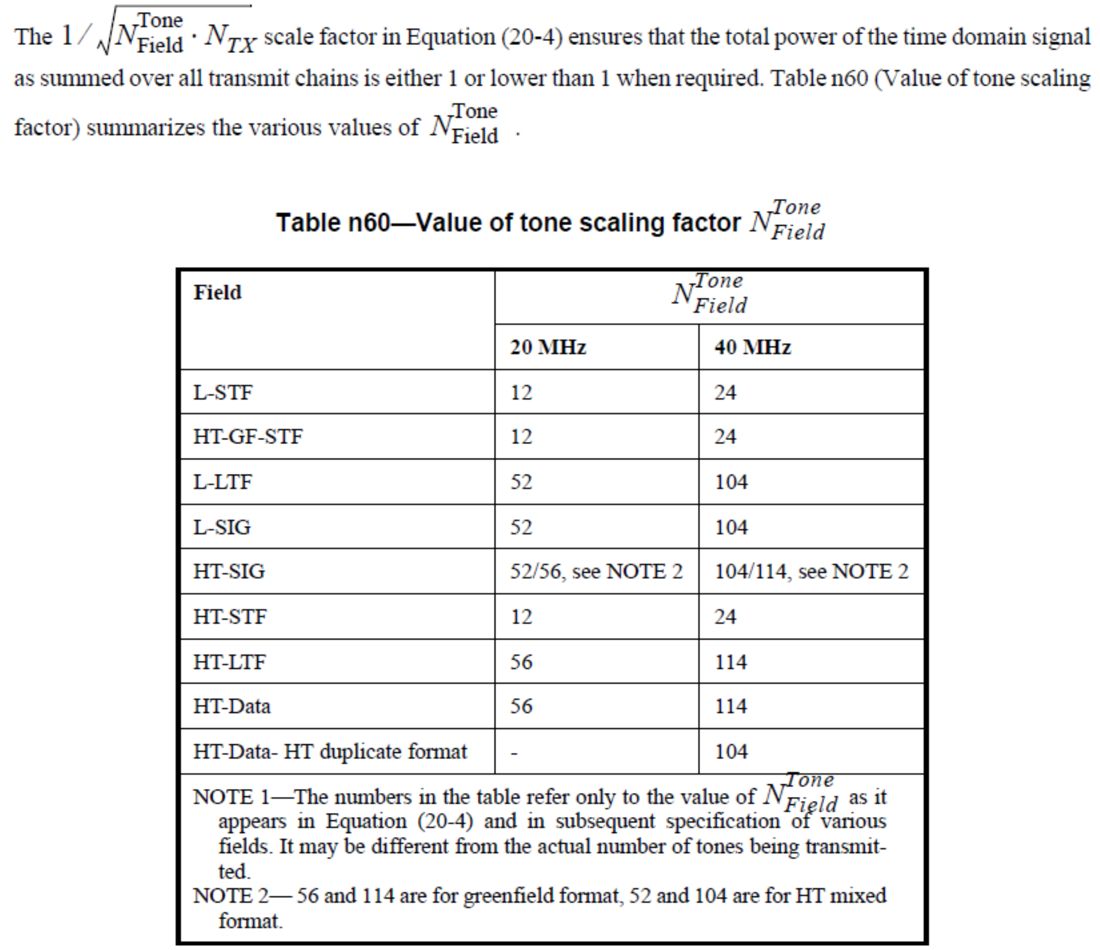
This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \quad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \quad (20\text{-}6)$$

Claim 17 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**



The $1/\sqrt{N_{\mathrm{Field}}^{\mathrm{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\mathrm{Field}}^{\mathrm{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	40 MHz
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

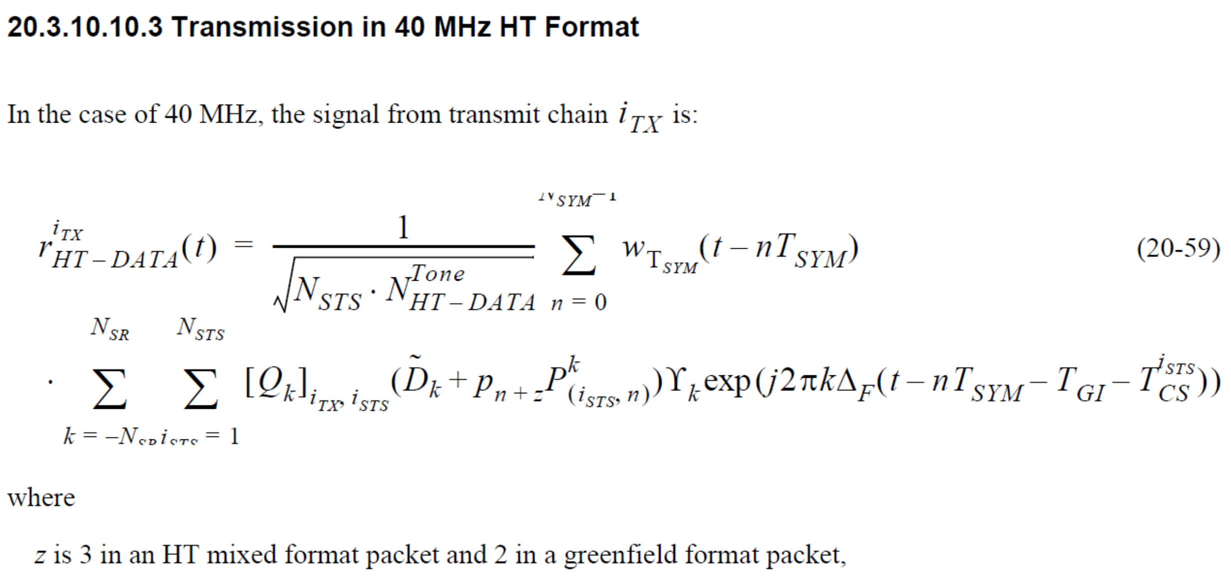
NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P_{(i_{STS},n)}^{k}) \exp(j 2 \pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (20-58) where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

Claim 17 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P_{(i_{STS}, n)}^k) \Upsilon_k \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (20-59) where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

<table>
<tr><th>Claim 17 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
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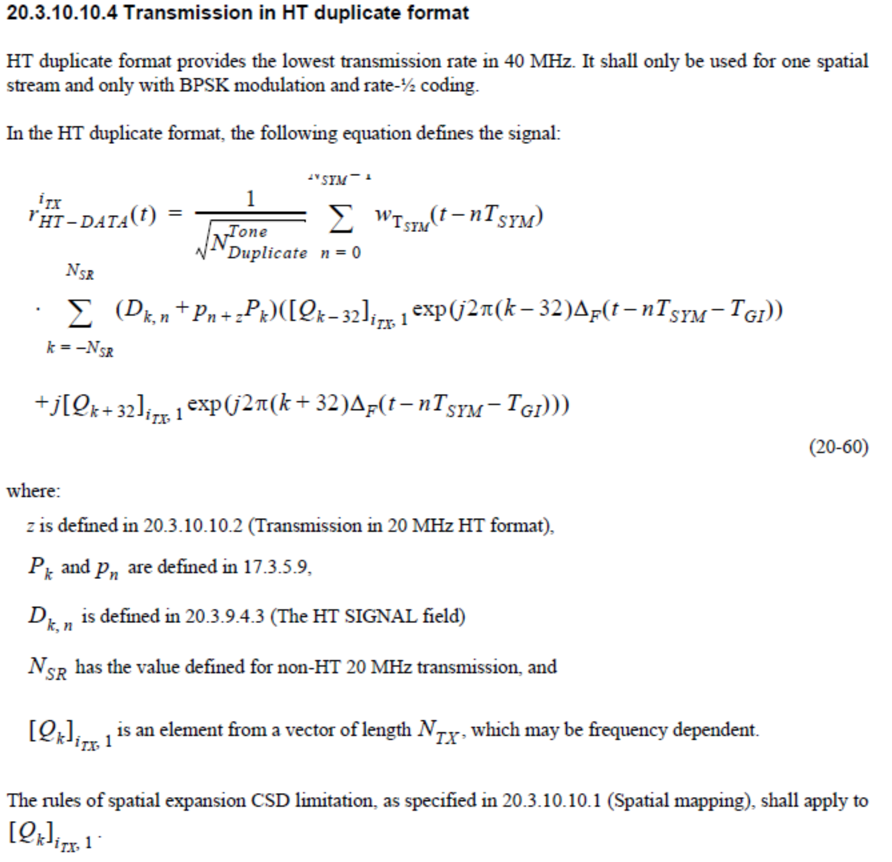

20.3.10.10.4 Transmission in HT duplicate format

HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding.

In the HT duplicate format, the following equation defines the signal:

$$r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n} + p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t - nT_{SYM} - T_{GI})) + j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t - nT_{SYM} - T_{GI}))) \quad (20\text{-}60)$$

where:

z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format),

P_k and p_n are defined in 17.3.5.9,

$D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field)

N_{SR} has the value defined for non-HT 20 MHz transmission, and

$[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent.

The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$.

See, e.g., 802.11n D2.0 § 20.3.10.10.4

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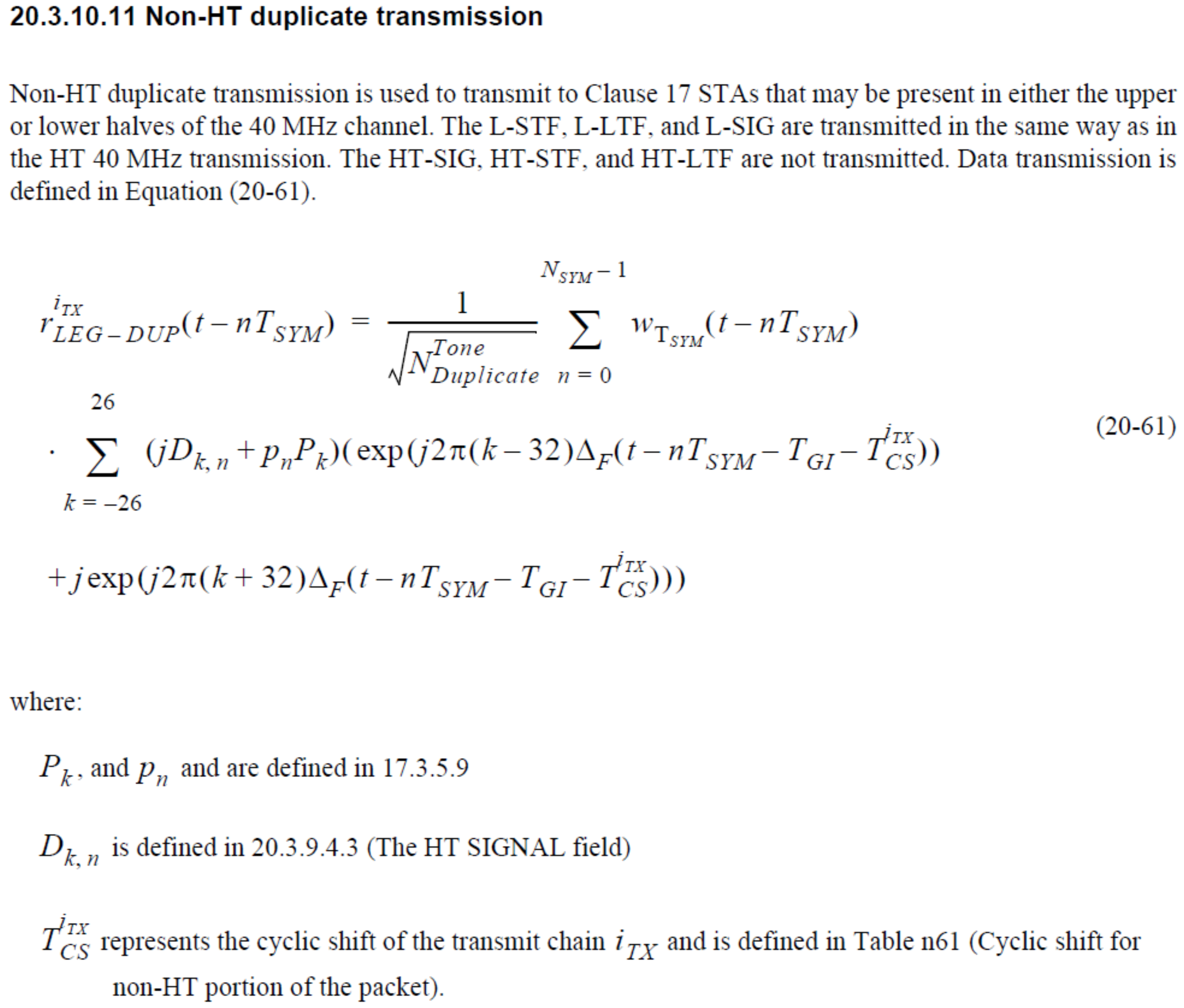
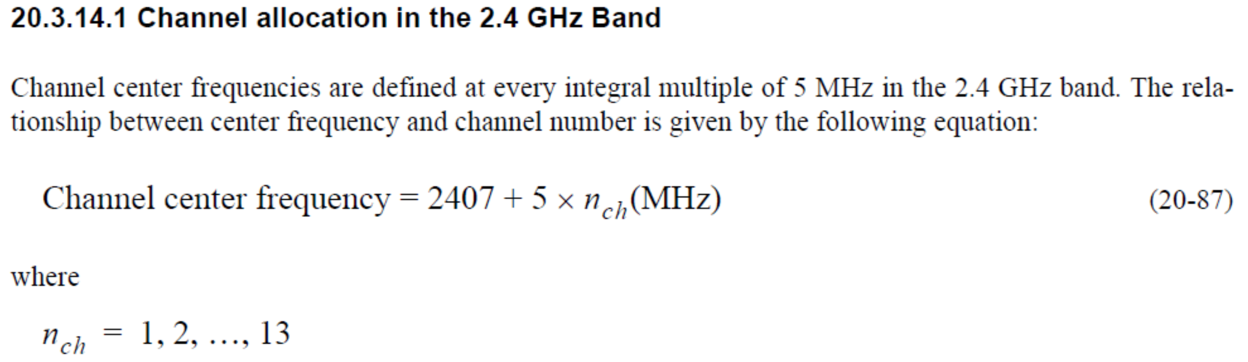
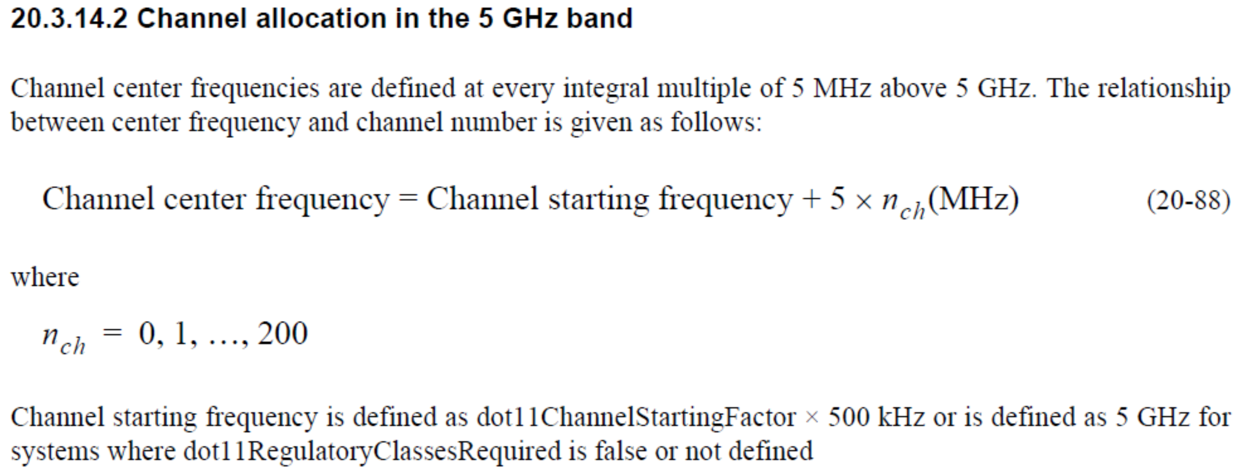
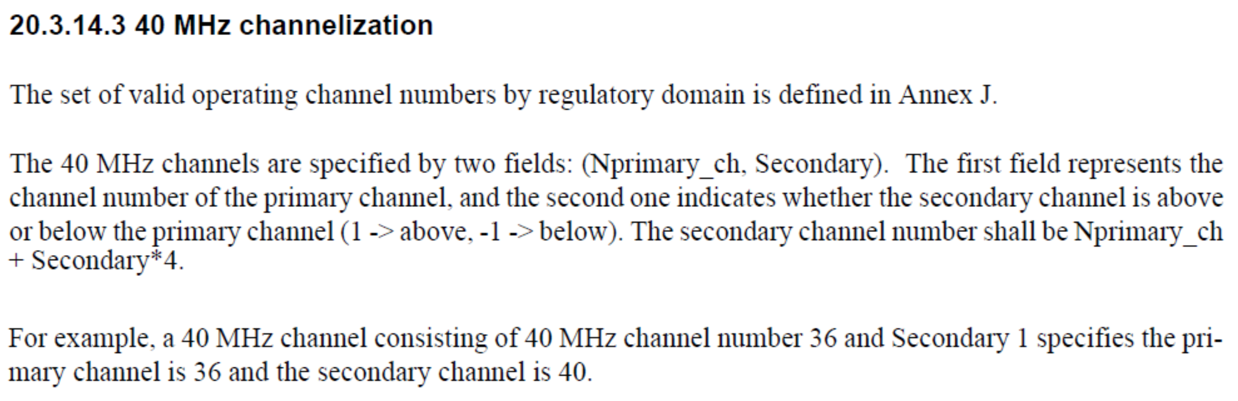
Claim 17 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	**20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r_{LEG-DUP}^{i_{TX}}(t-nT_{SYM}) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n}+p_n P_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{TX}})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{TX}})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T_{CS}^{i_{TX}}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz}) \qquad (20\text{-}87)$ where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz}) \qquad (20\text{-}88)$ where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

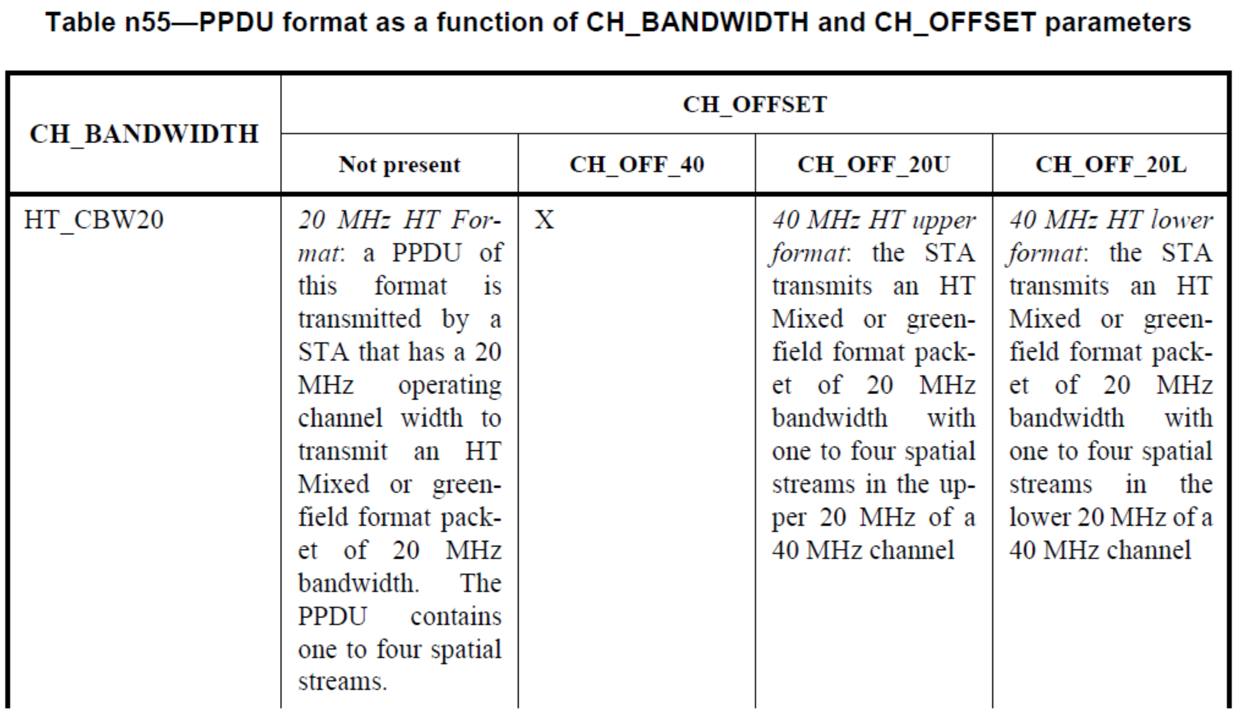
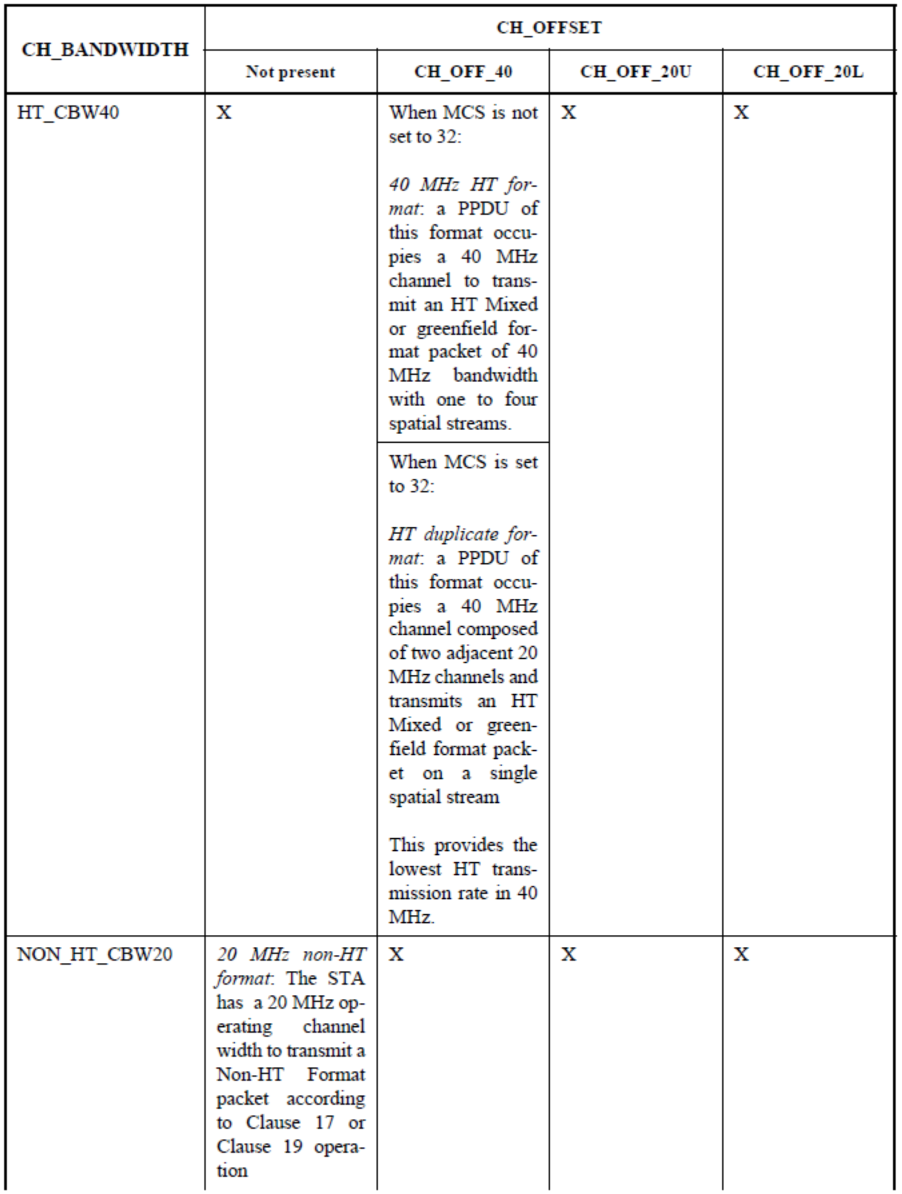
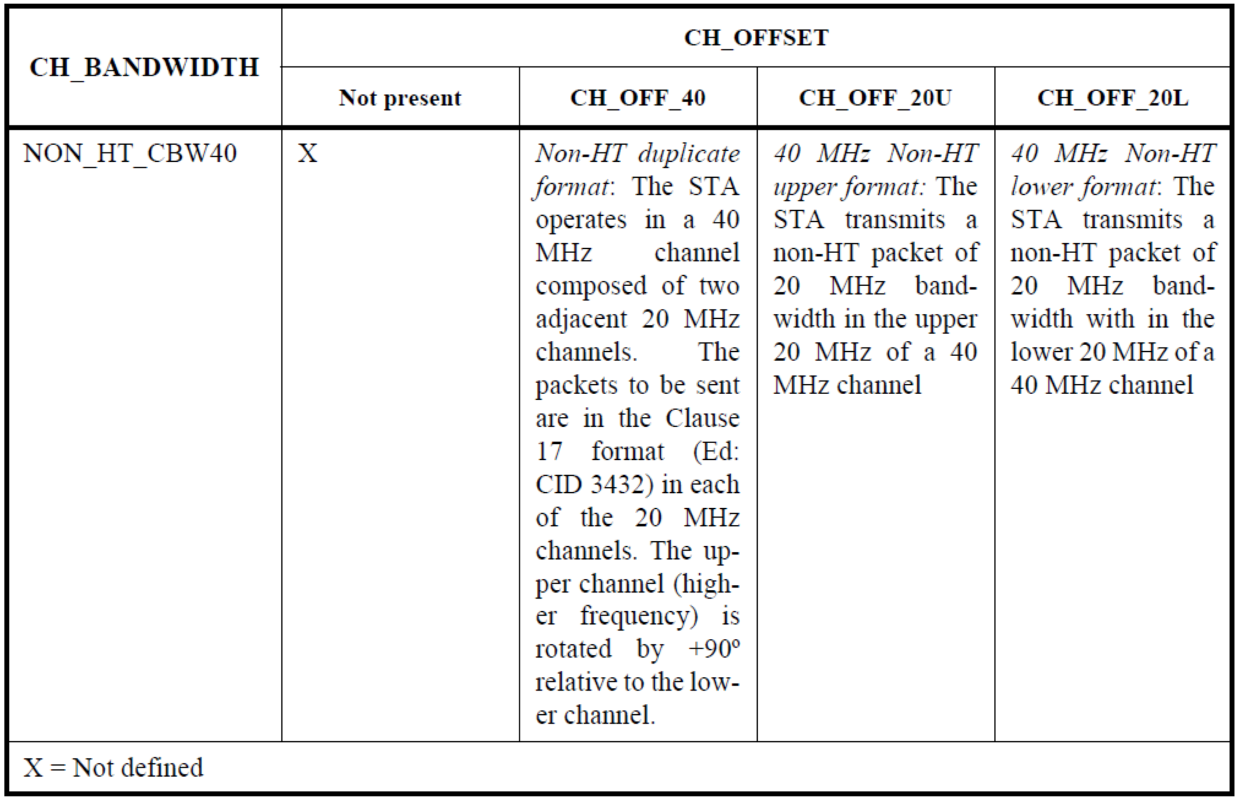
Claim 17 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.20.3 

Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

CH_BANDWIDTH	**CH_OFFSET**			
	Not present	**CH_OFF_40**	**CH_OFF_20U**	**CH_OFF_20L**
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel



CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams.	X	X
		When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.		
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 See, e.g., 802.11n D2.0 Table n55

CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
NON_HT_CBW40	X	*Non-HT duplicate format*: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.	*40 MHz Non-HT upper format:* The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel	*40 MHz Non-HT lower format*: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel
X = Not defined				

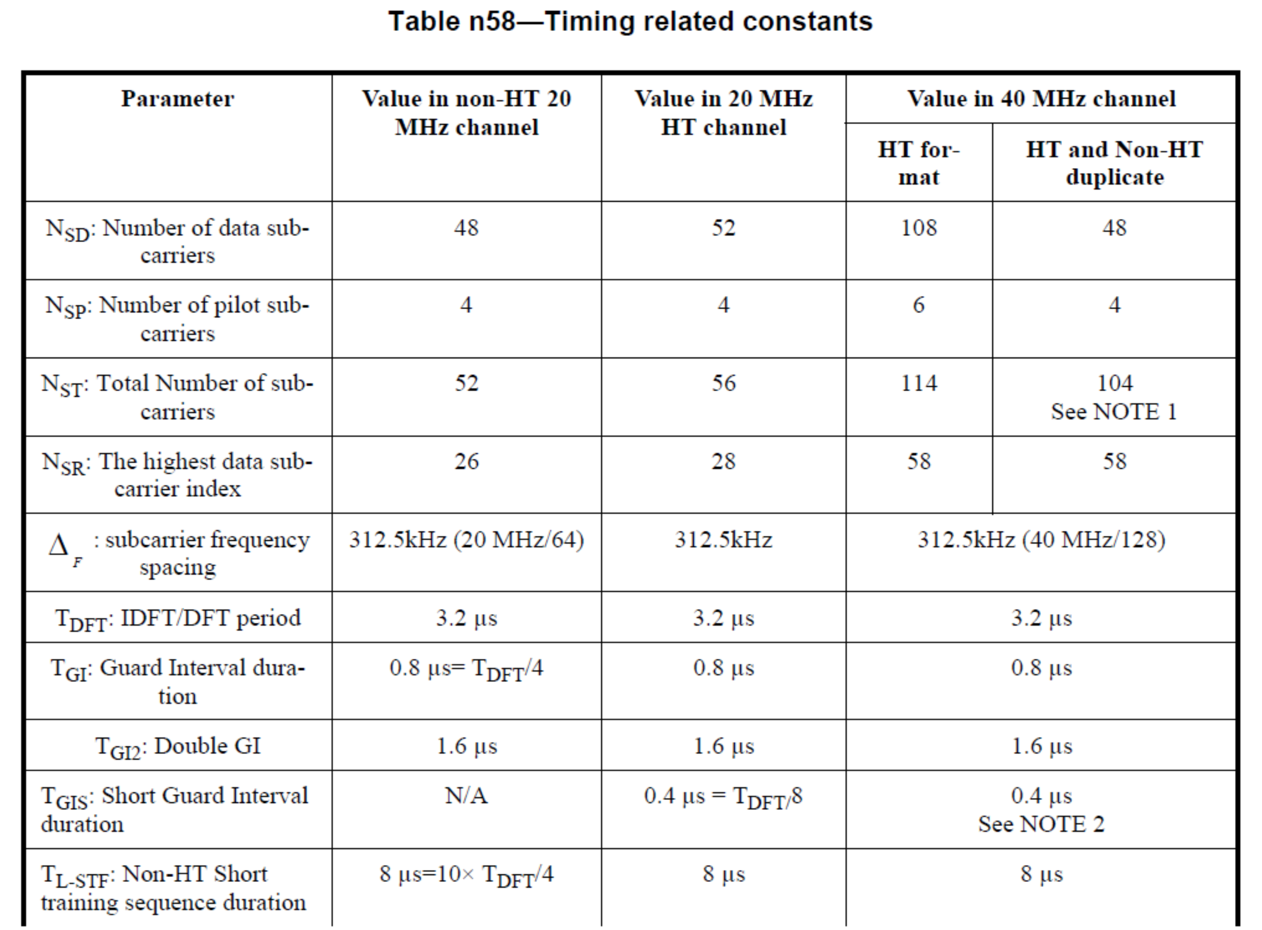
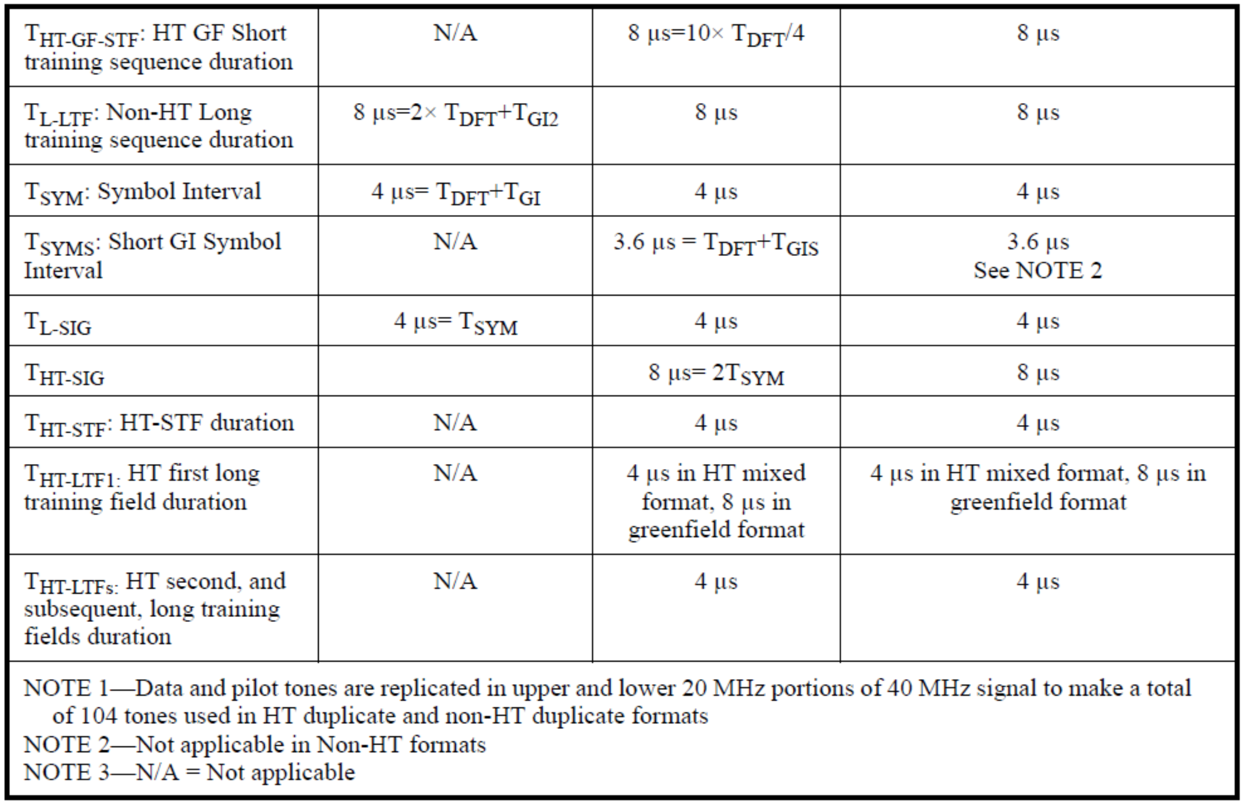
Claim 17 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	

Table n58—Timing related constants

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	$0.8\ \mu s = T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	$0.4\ \mu s = T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	$8\ \mu s = 10 \times T_{DFT}/4$	8 µs	8 µs	

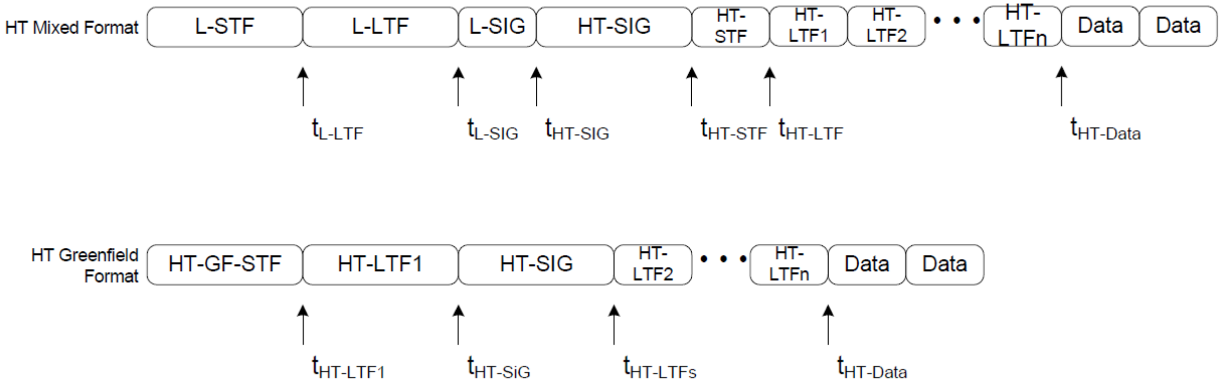
Claim 17 of the '802 Patent	Prior Art Reference – 802.11n D2.0



$T_{HT\text{-}GF\text{-}STF}$: HT GF Short training sequence duration	N/A	8 μs=10× $T_{DFT}/4$	8 μs
$T_{L\text{-}LTF}$: Non-HT Long training sequence duration	8 μs=2× $T_{DFT}+T_{GI2}$	8 μs	8 μs
T_{SYM}: Symbol Interval	4 μs= $T_{DFT}+T_{GI}$	4 μs	4 μs
T_{SYMS}: Short GI Symbol Interval	N/A	3.6 μs = $T_{DFT}+T_{GIS}$	3.6 μs See NOTE 2
$T_{L\text{-}SIG}$	4 μs= T_{SYM}	4 μs	4 μs
$T_{HT\text{-}SIG}$		8 μs= $2T_{SYM}$	8 μs
$T_{HT\text{-}STF}$: HT-STF duration	N/A	4 μs	4 μs
$T_{HT\text{-}LTF1}$: HT first long training field duration	N/A	4 μs in HT mixed format, 8 μs in greenfield format	4 μs in HT mixed format, 8 μs in greenfield format
$T_{HT\text{-}LTFs}$: HT second, and subsequent, long training fields duration	N/A	4 μs	4 μs

NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable

See, e.g., 802.11n D2.0 Table n58

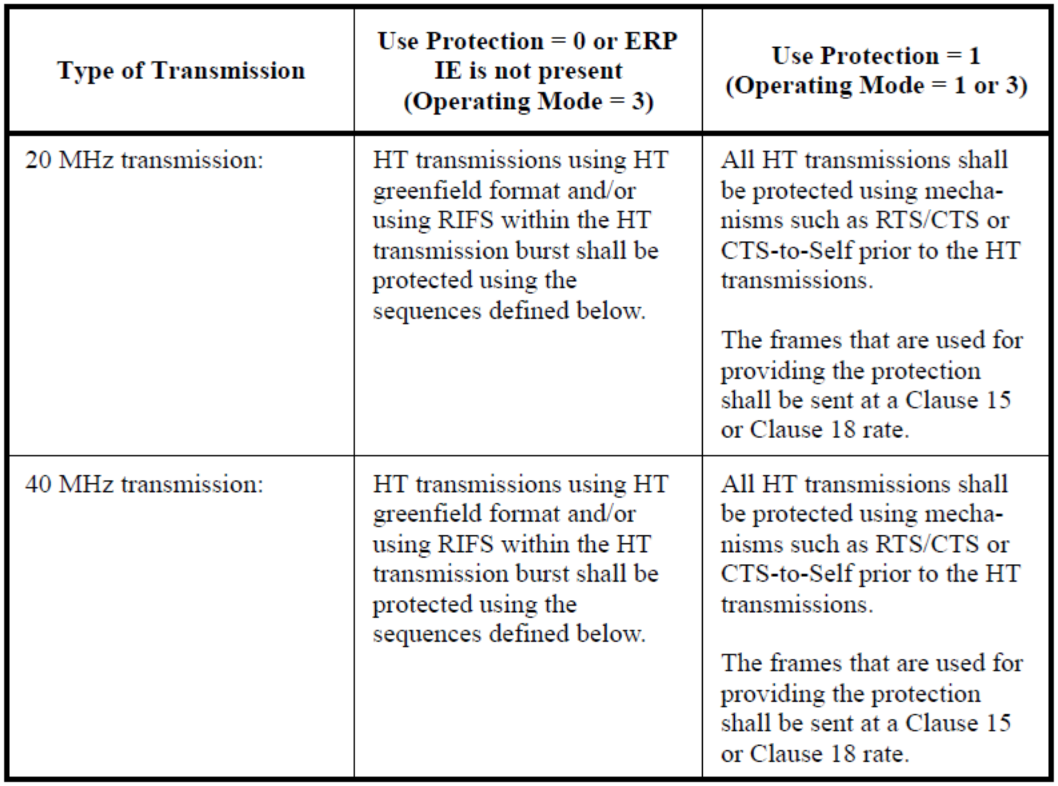
Claim 17 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.

Claim 21 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
[21.1] The communication system of claim 17	802.11n D2.0 discloses all the elements of claim 17 for all the reasons provided above.

Claim 21 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
[21.2] wherein the first data of the first digital signal is encoded using a first wireless protocol and the first data of the second digital signal is encoded using a second wireless protocol.	802.11n D2.0 discloses “wherein the first data of the first digital signal is encoded using a first wireless protocol and the first data of the second digital signal is encoded using a second wireless protocol.” See, e.g.: **high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19 **non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that

Claim 21 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

Table n49—Protection requirements for Operating Modes of 1 and 3



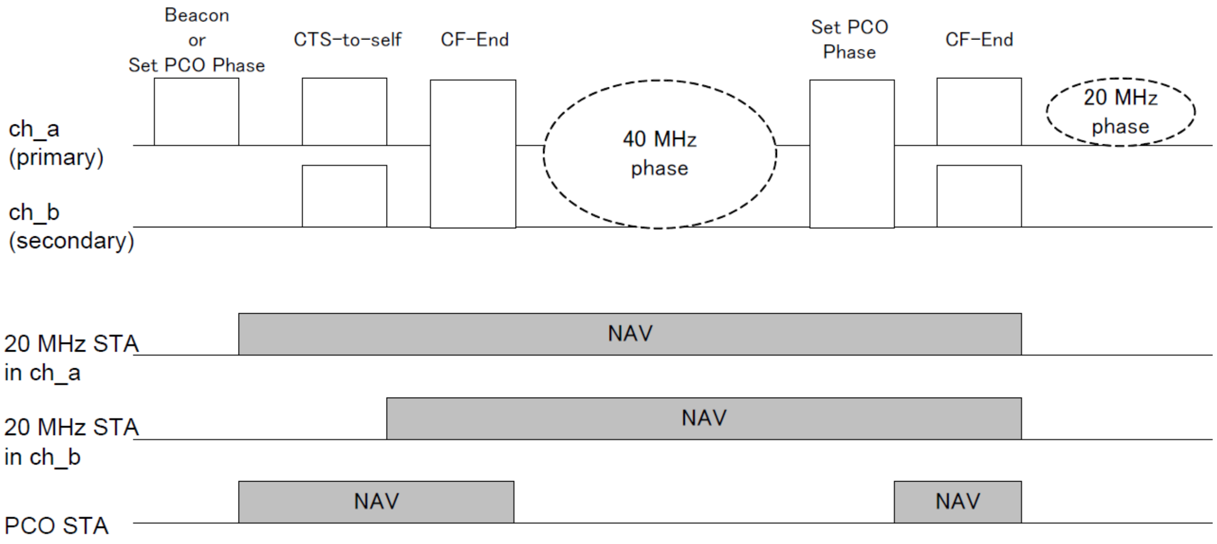
Type of Transmission	Use Protection = 0 or ERP IE is not present (Operating Mode = 3)	Use Protection = 1 (Operating Mode = 1 or 3)
20 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.
40 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:

a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:

1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19

Claim 21 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20. NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames). b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

Claim 21 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

Claim 21 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 21 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

Claim 21 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

Claim 21 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

Claim 21 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $$r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t \right) \right\} \qquad (20\text{-}1)$$ where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

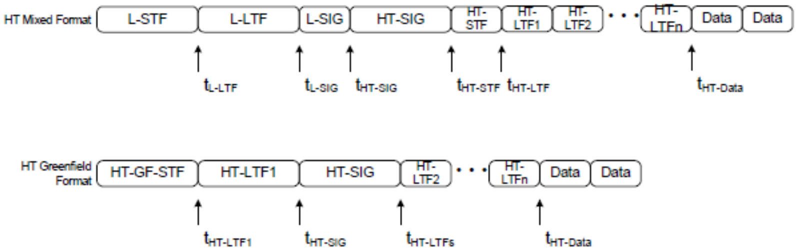


Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) \;=\; & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right)T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \tag{20-2}$$

where

$$t_{L-LTF} = T_{L-STF}$$

$$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$$

$$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$$

$$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r^{(i_{TX})}_{PPDU}(t) = {} & r^{(i_{TX})}_{HT-GF-STF}(t) + r^{(i_{TX})}_{HT-LTF1}(t - t_{HT-LTF1}) \\ & + r^{(i_{TX})}_{HT-SIG}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r^{(i_{TX}, i_{LTF})}_{HT-LTF}(t - t_{HT-LTFs} - (i_{LTF} - 2) T_{HT-LTFs}) \\ & + r^{(i_{TX})}_{HT-DATA}(t - t_{HT-DATA}) \end{aligned} \qquad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r^{(i_{TX})}_{\text{Field}}(t)$, is defined via the discrete Fourier transform as

$$r^{(i_{TX})}_{\text{Field}}(t) = \frac{1}{\sqrt{N^{\text{Tone}}_{\text{Field}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X^{(i_{TX})}_k \exp(j 2\pi k \Delta_F t) \qquad (20\text{-}4)$$

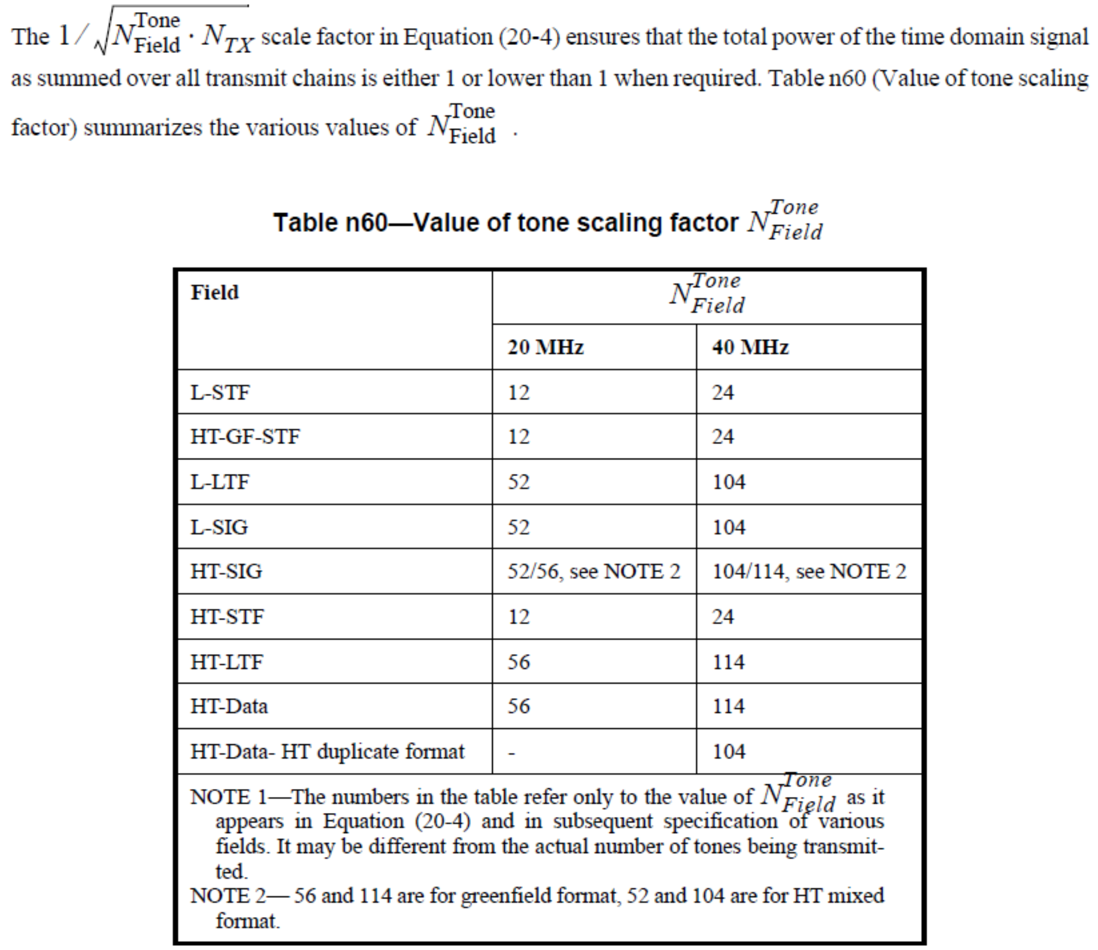
This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X^{(i_{TX})}_k$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \qquad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \qquad (20\text{-}6)$$

Claim 21 of the ’802 Patent	Prior Art Reference – 802.11n D2.0



The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	40 MHz
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

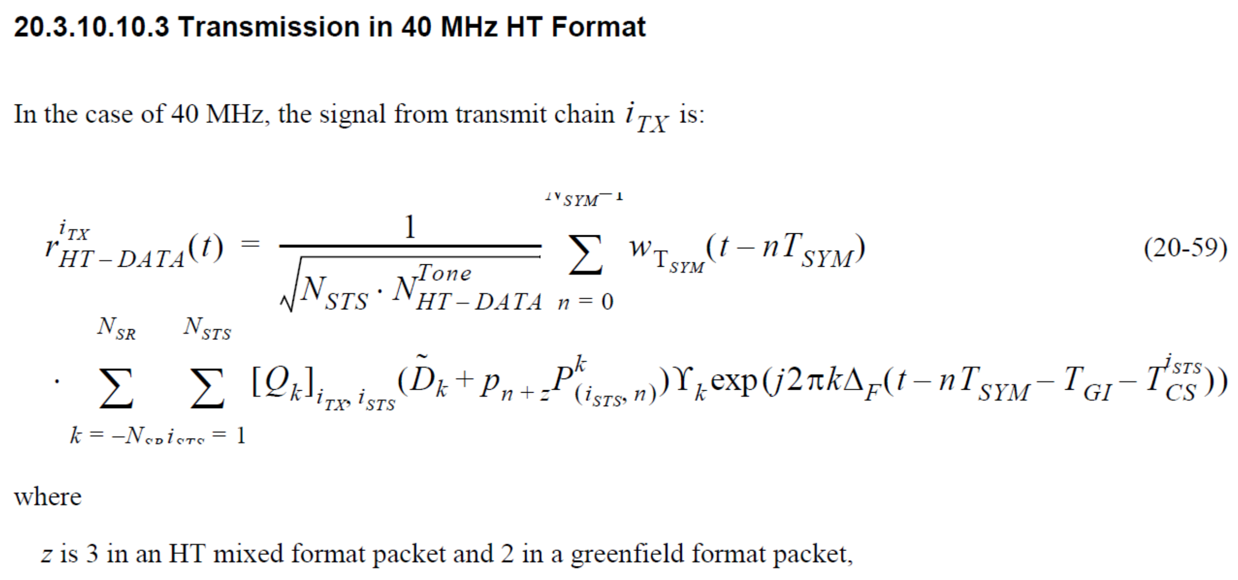
NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

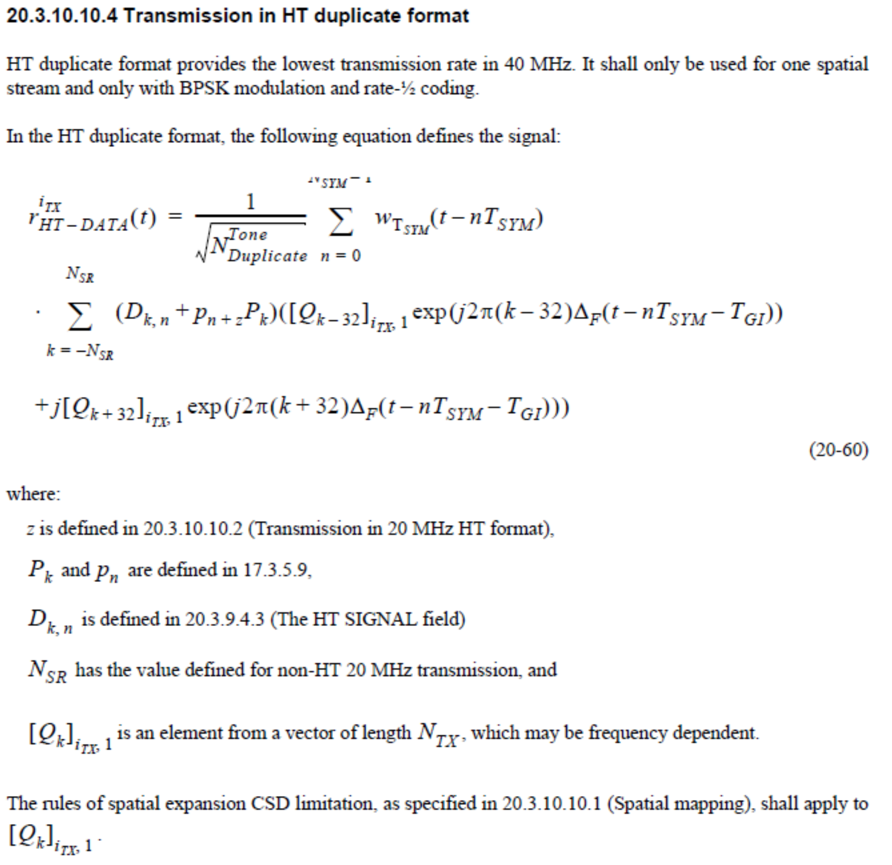
See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

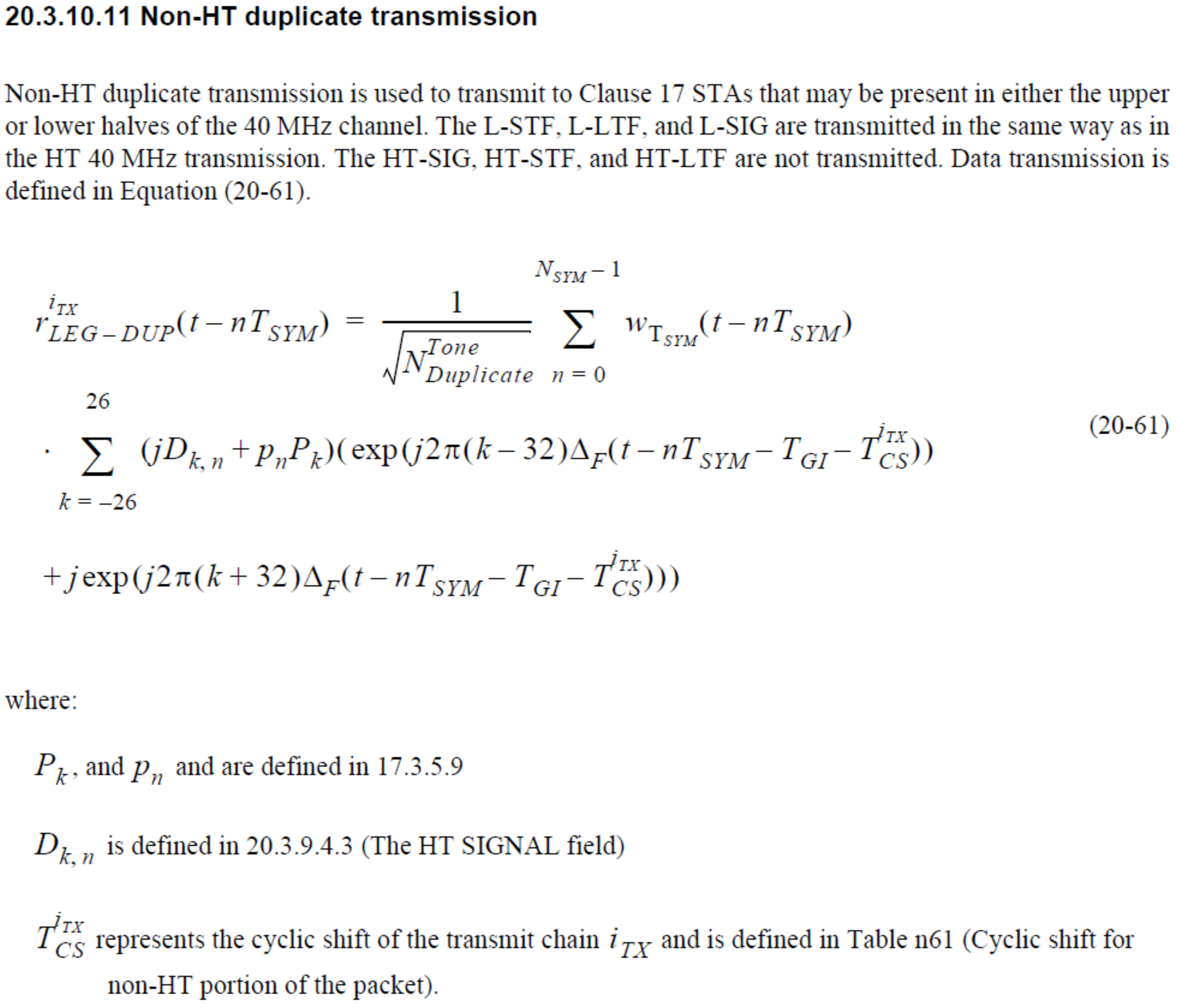
20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

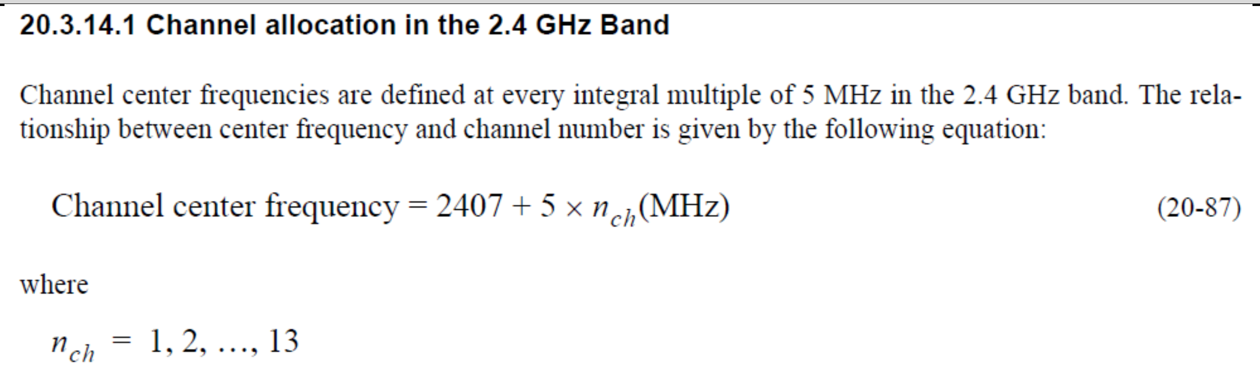
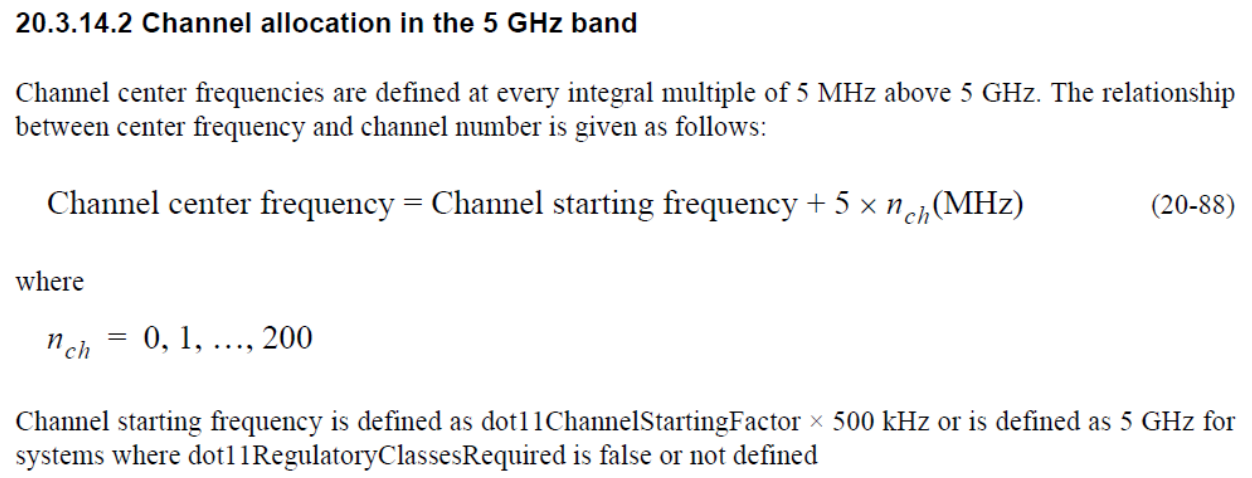
When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

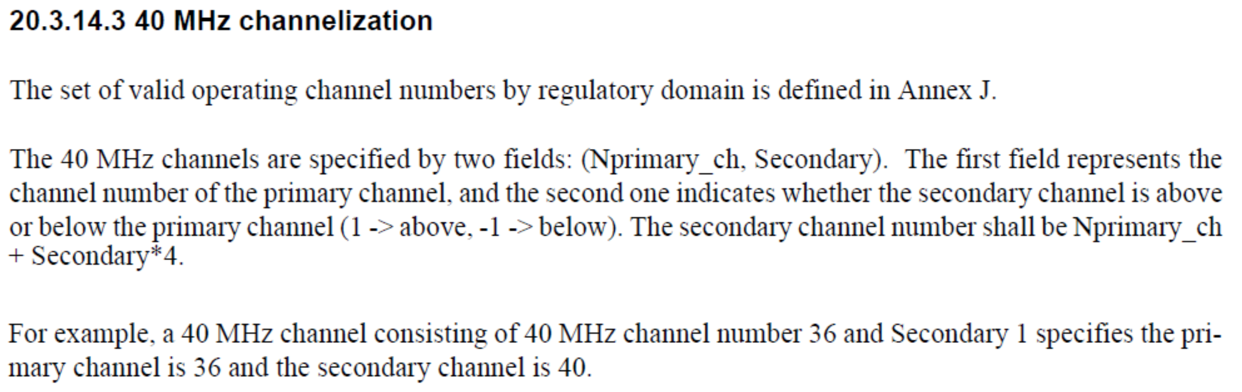
Claim 21 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $$D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $$r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS} \cdot N^{Tone}_{HT-DATA}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \quad (20\text{-}58)$$ $$\cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P^k_{(i_{STS},n)}) \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T^{i_{STS}}_{CS}))$$ where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

Claim 21 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $$r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS}\cdot N^{Tone}_{HT-DATA}}}\sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}}\sum_{i_{STS}=1}^{N_{STS}}[Q_k]_{i_{TX},i_{STS}}(\tilde{D}_k + p_{n+z}P^k_{(i_{STS},n)})\Upsilon_k \exp(j2\pi k\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{STS}}_{CS})) \quad (20\text{-}59)$$ where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

Claim 21 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM})$ $\cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n} + p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t - nT_{SYM} - T_{GI}))$ $+ j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t - nT_{SYM} - T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

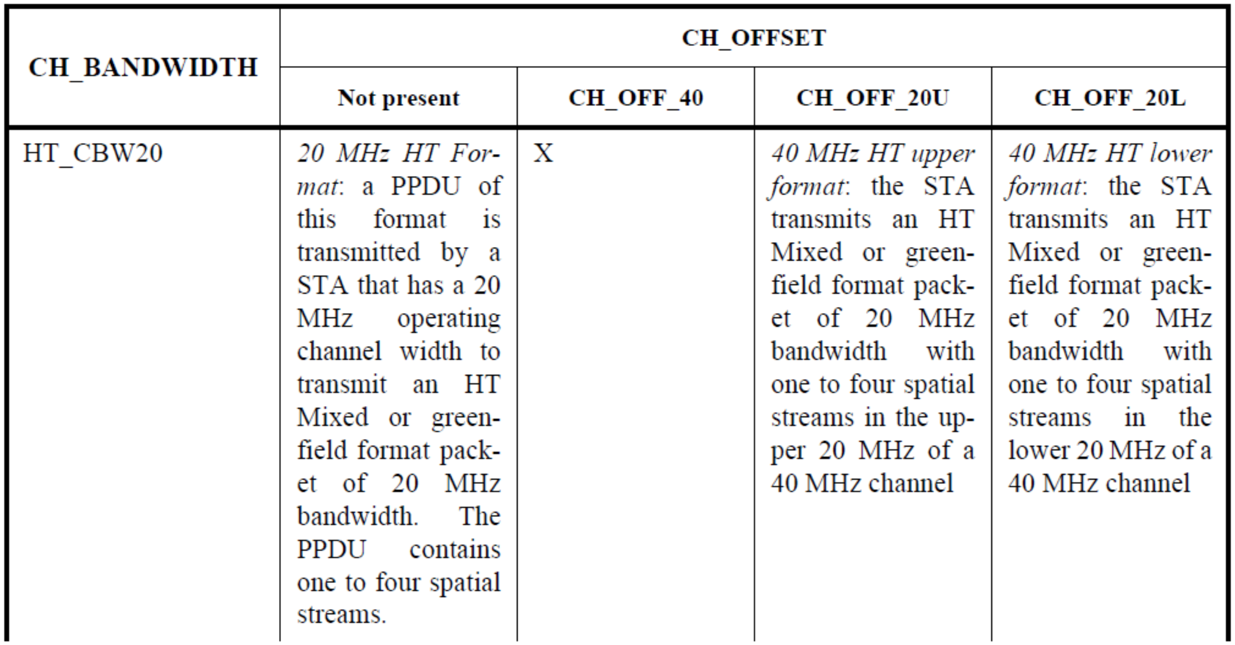
Claim 21 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r^{i_{TX}}_{LEG-DUP}(t-nT_{SYM}) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}}\sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26}(jD_{k,n}+p_nP_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T^{i_{TX}}_{CS}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 21 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch} (\text{MHz}) \quad (20\text{-}87)$ where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch} (\text{MHz}) \quad (20\text{-}88)$ where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

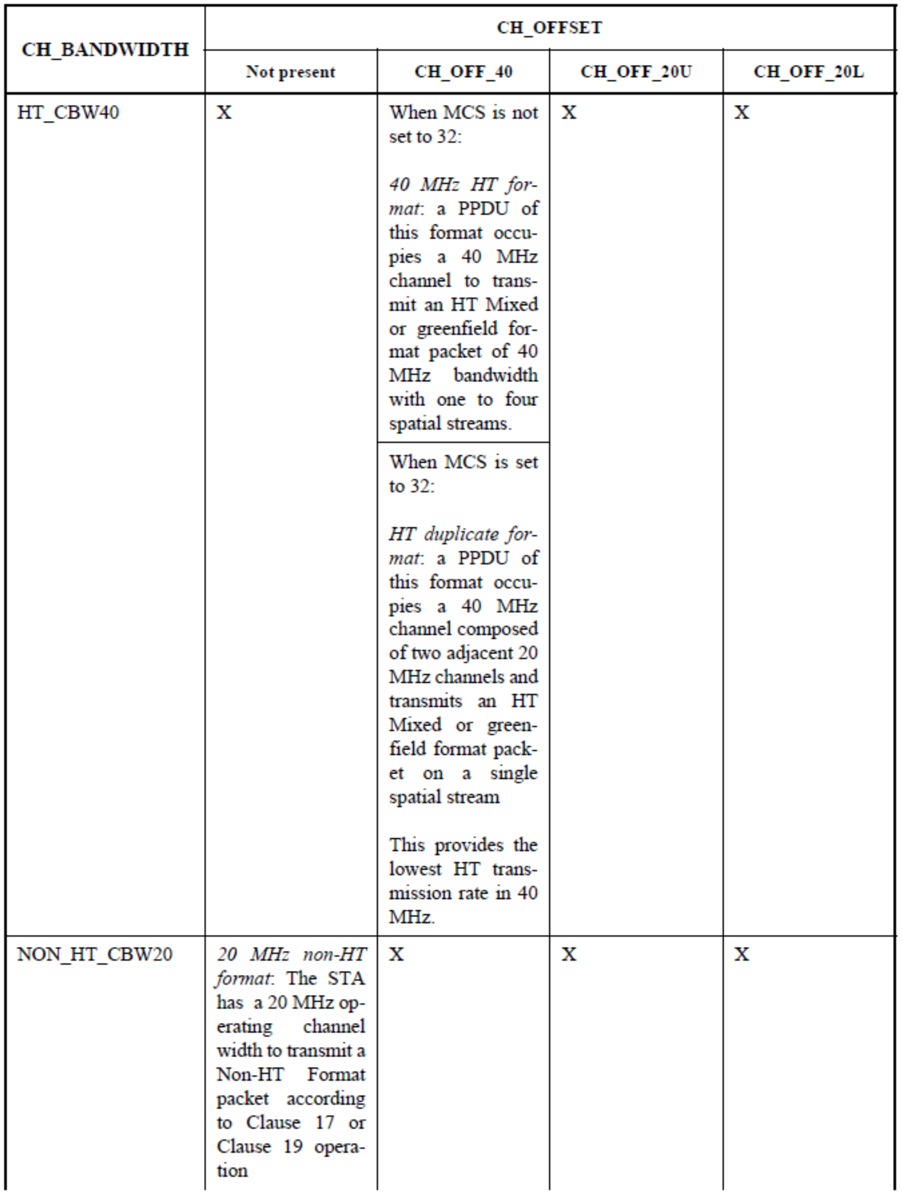
Claim 21 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

Claim 21 of the '802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.20.3

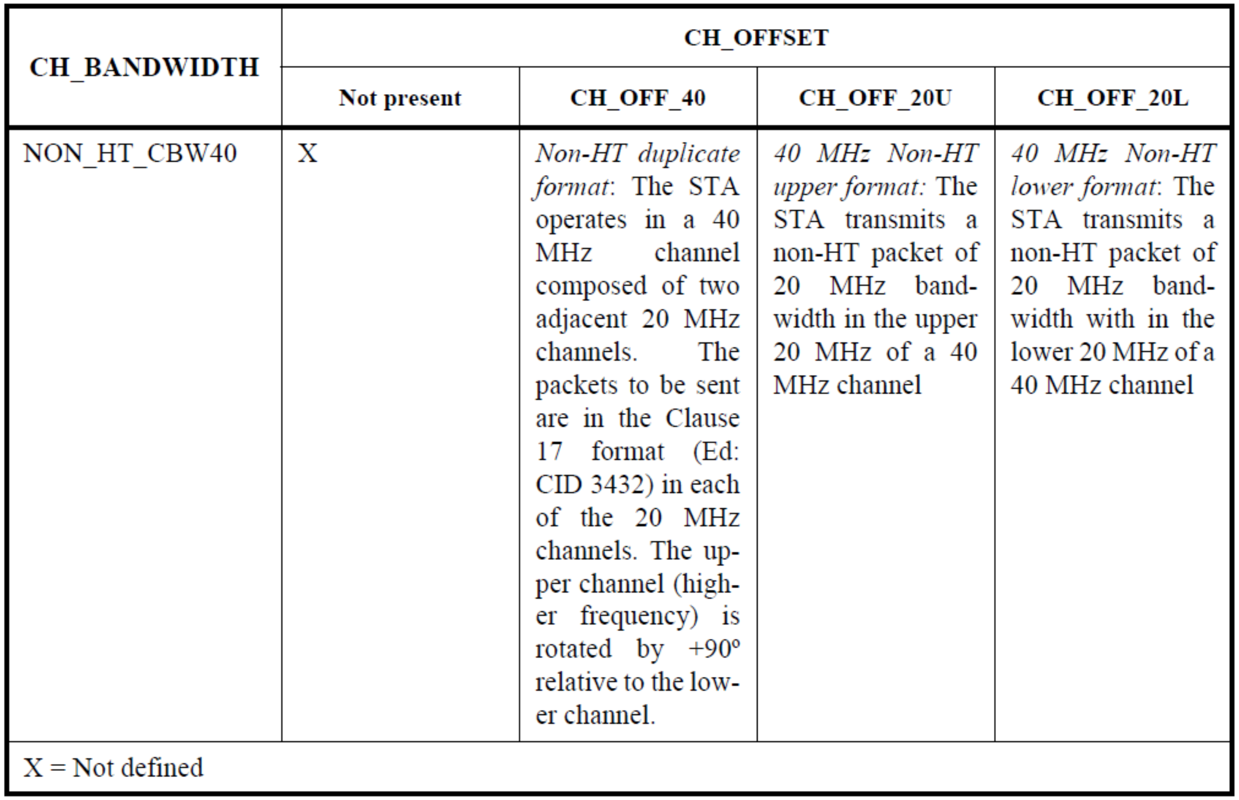
Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters



CH_BANDWIDTH	**CH_OFFSET**			
	Not present	**CH_OFF_40**	**CH_OFF_20U**	**CH_OFF_20L**
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel



CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

<table>
<tr><th>Claim 21 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>NON_HT_CBW40</td><td>X</td><td><i>Non-HT duplicate format</i>: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90° relative to the lower channel.</td><td><i>40 MHz Non-HT upper format:</i> The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel</td><td><i>40 MHz Non-HT lower format</i>: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel</td></tr>
<tr><td colspan="5">X = Not defined</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n55
</td></tr>
</table>

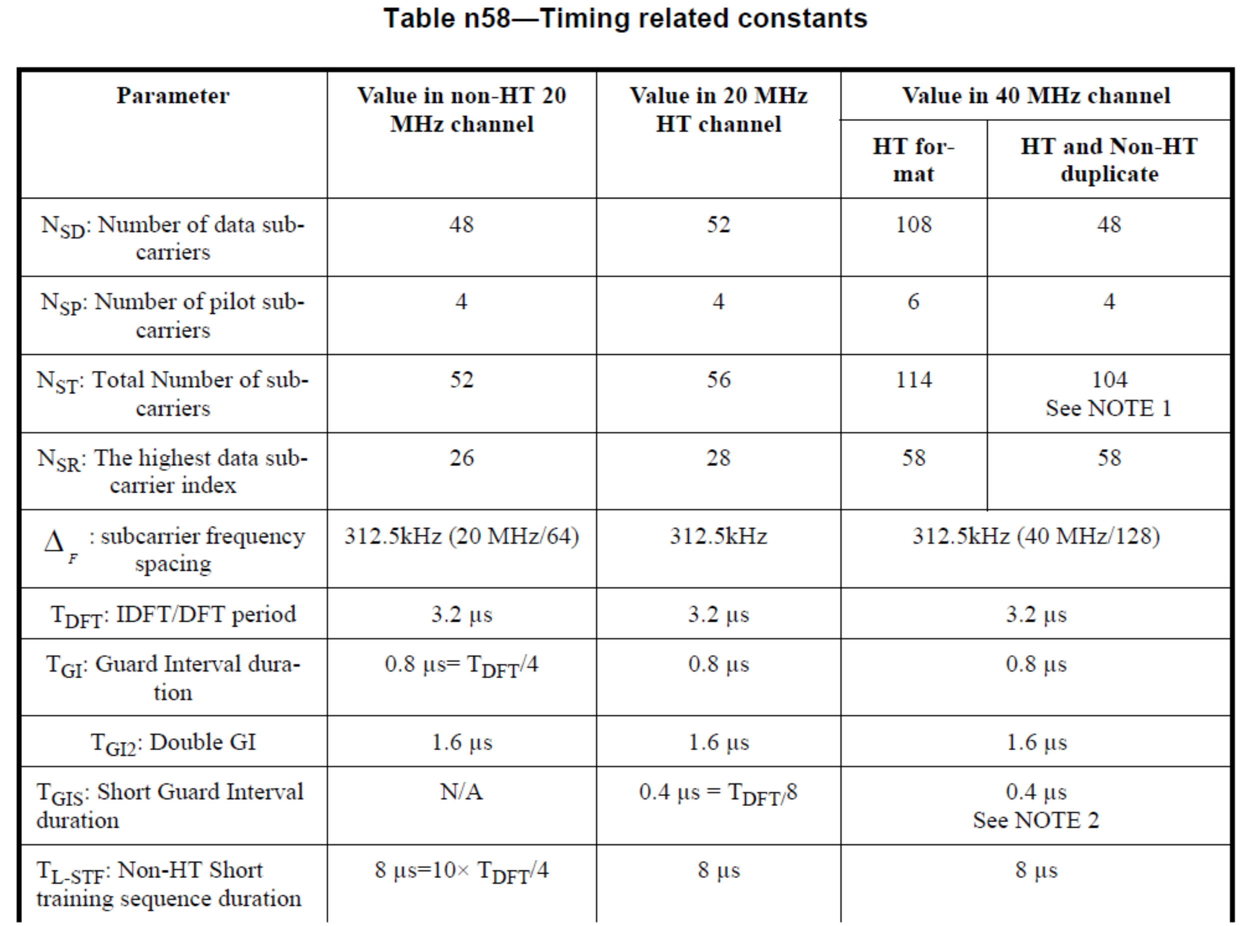
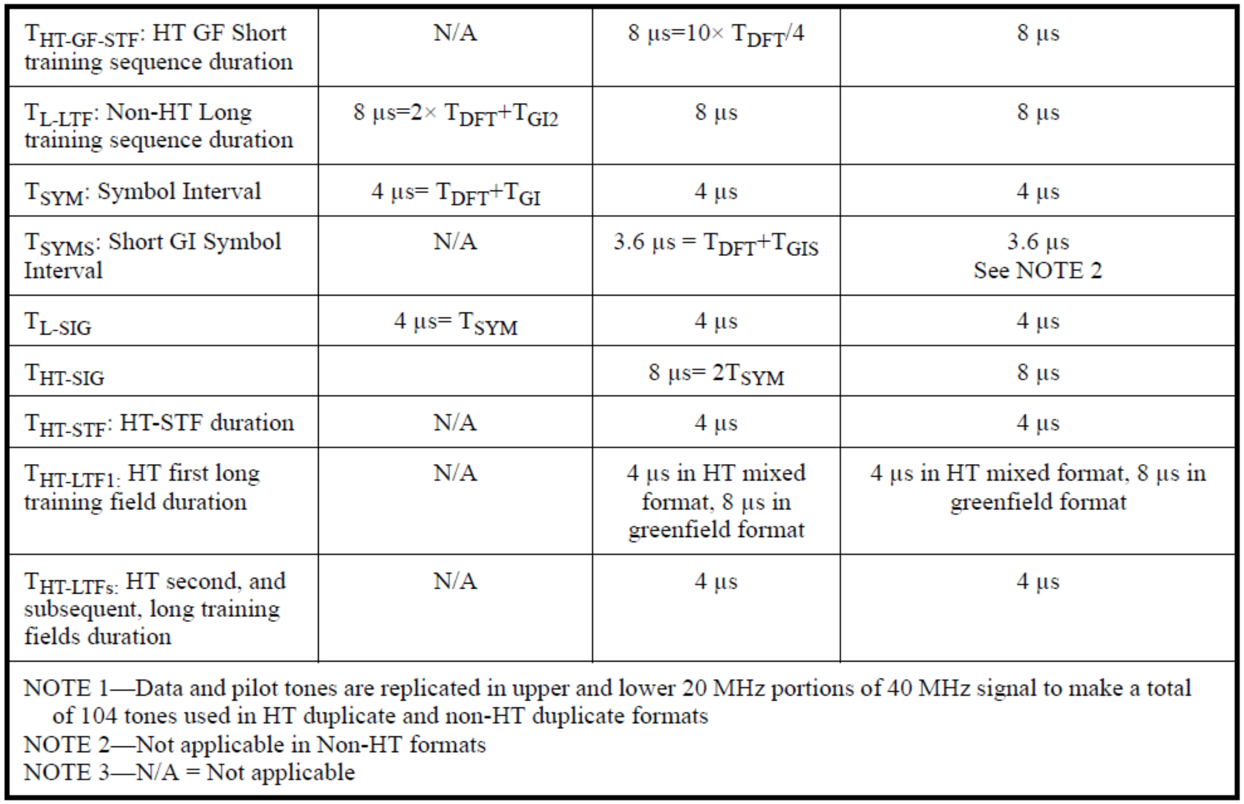
Claim 21 of the '802 Patent	**Prior Art Reference – 802.11n D2.0**
	

Table n58—Timing related constants

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

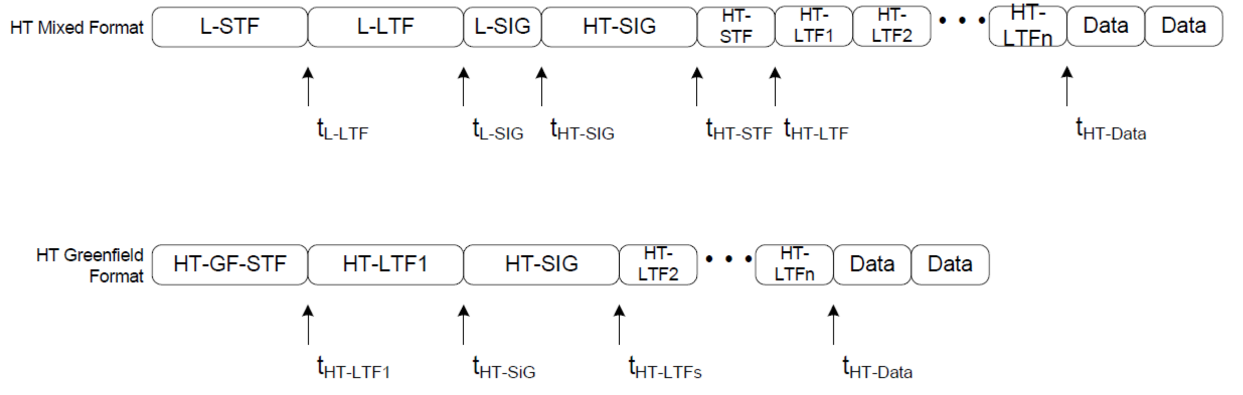
Claim 21 of the ’802 Patent	Prior Art Reference – 802.11n D2.0



$T_{\text{HT-GF-STF}}$: HT GF Short training sequence duration	N/A	8 μs=10× $T_{\text{DFT}}/4$	8 μs
$T_{\text{L-LTF}}$: Non-HT Long training sequence duration	8 μs=2× $T_{\text{DFT}}+T_{\text{GI2}}$	8 μs	8 μs
T_{SYM}: Symbol Interval	4 μs= $T_{\text{DFT}}+T_{\text{GI}}$	4 μs	4 μs
T_{SYMS}: Short GI Symbol Interval	N/A	3.6 μs = $T_{\text{DFT}}+T_{\text{GIS}}$	3.6 μs See NOTE 2
$T_{\text{L-SIG}}$	4 μs= T_{SYM}	4 μs	4 μs
$T_{\text{HT-SIG}}$		8 μs= 2T_{SYM}	8 μs
$T_{\text{HT-STF}}$: HT-STF duration	N/A	4 μs	4 μs
$T_{\text{HT-LTF1:}}$ HT first long training field duration	N/A	4 μs in HT mixed format, 8 μs in greenfield format	4 μs in HT mixed format, 8 μs in greenfield format
$T_{\text{HT-LTFs:}}$ HT second, and subsequent, long training fields duration	N/A	4 μs	4 μs

NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable

See, e.g., 802.11n D2.0 Table n58

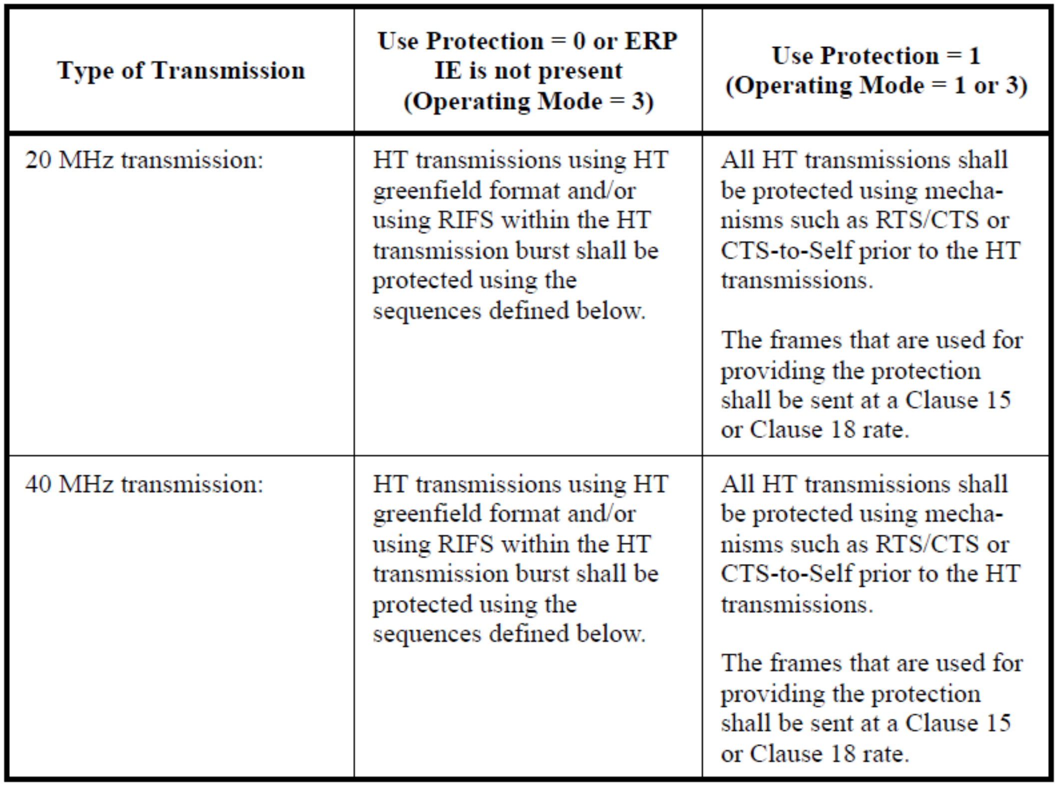
Claim 21 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.

Claim 22 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
[22.1] The communication system of claim 17	802.11n D2.0 discloses all the elements of claim 17 for all the reasons provided above.

Claim 22 of the '802 Patent	**Prior Art Reference – 802.11n D2.0**
[22.2] wherein the second data corresponds to the first data and wherein the power amplifier outputs a third up-converted signal comprising the up-converted first analog signal and the up-converted second analog signal.	802.11n D2.0 discloses "wherein the second data corresponds to the first data and wherein the power amplifier outputs a third up-converted signal comprising the up-converted first analog signal and the up-converted second analog signal." See, e.g.: **high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19 **non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that

Claim 22 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

Table n49—Protection requirements for Operating Modes of 1 and 3



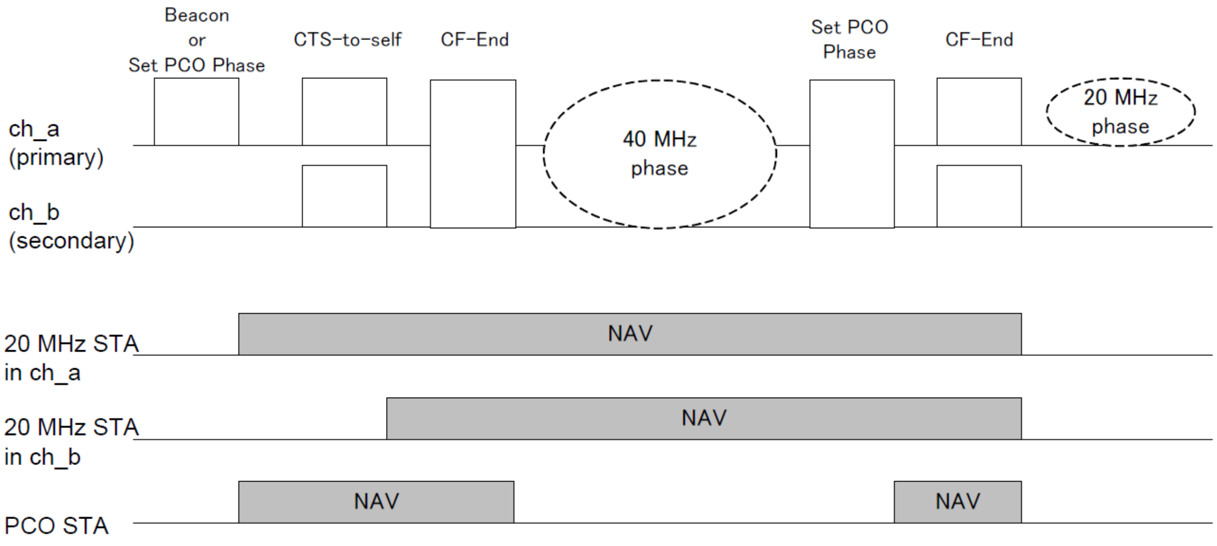
Type of Transmission	Use Protection = 0 or ERP IE is not present (Operating Mode = 3)	Use Protection = 1 (Operating Mode = 1 or 3)
20 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.
40 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:

a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:

1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19

Claim 22 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20. NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames). b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

Claim 22 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

Claim 22 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

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	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

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	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

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	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

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	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t \right) \right\}$ (20-1) where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

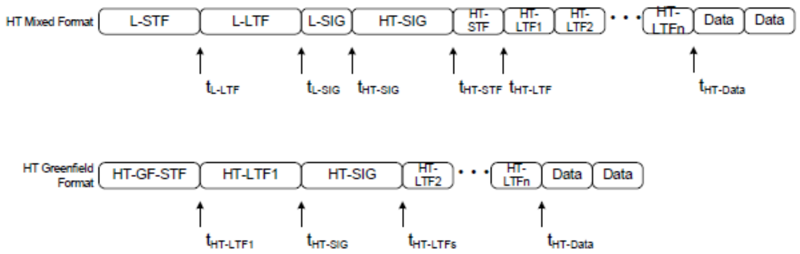

Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field}, determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) &= r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}(t - t_{L-LTF}) \\ &\quad + r_{L-SIG}^{(i_{TX})}(t - t_{L-SIG}) \\ &\quad + r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG}) \\ &\quad + r_{HT-STF}^{(i_{TX})}(t - t_{HT-STF}) \\ &\quad + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - (i_{LTF}-1)T_{HT-LTFs}\right) \\ &\quad + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \tag{20-2}$$

where

$t_{L-LTF} = T_{L-STF}$

$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$

$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$

$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1}) \\ & + r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2)T_{HT-LTFs}) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \tag{20-3}$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\text{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\text{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j2\pi k \Delta_F t) \tag{20-4}$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \tag{20-5}$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \tag{20-6}$$

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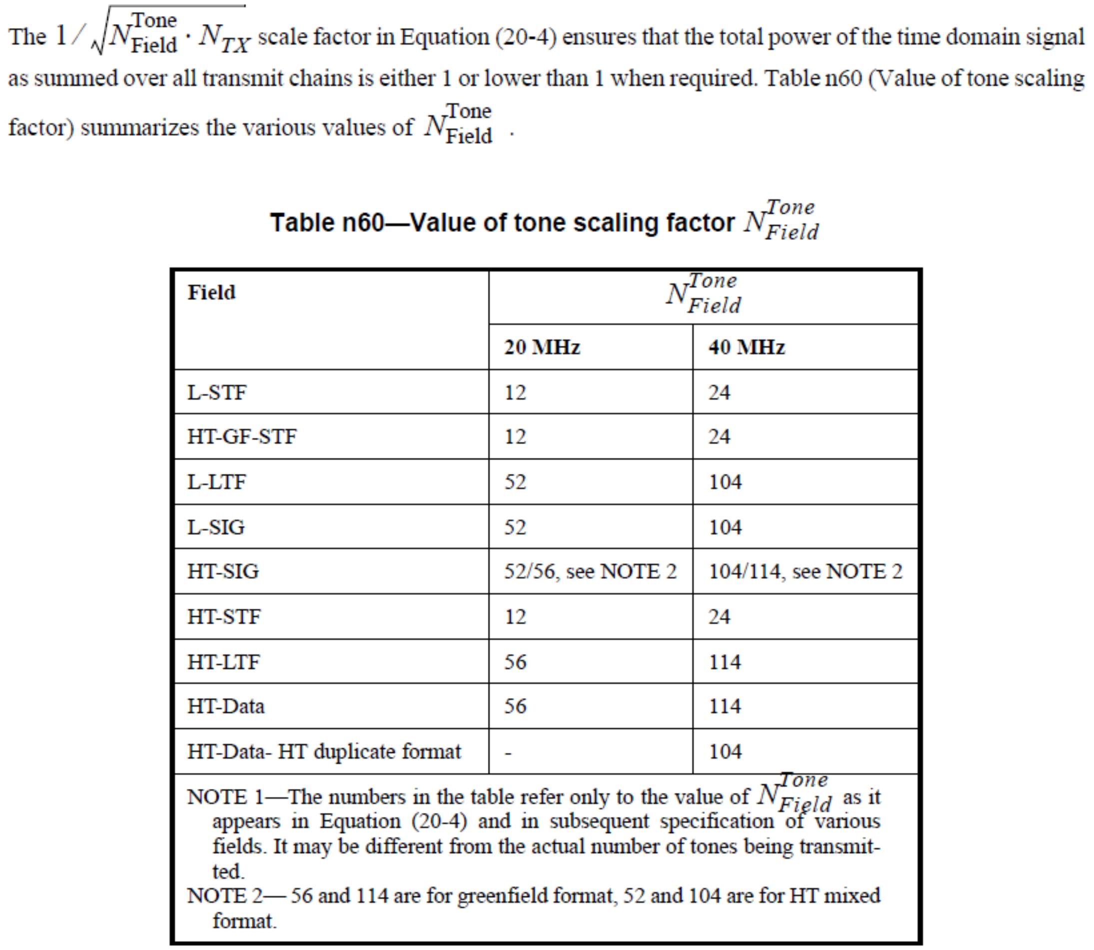

The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	**40 MHz**
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

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	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM})$ (20-58) $\cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P^k_{(i_{STS}, n)}) \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

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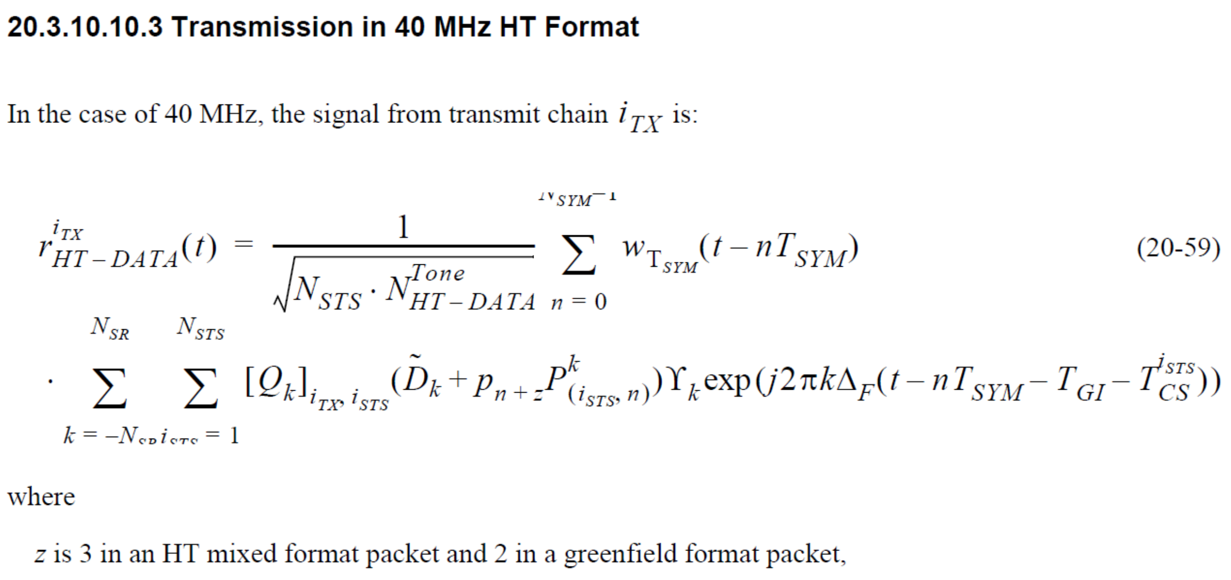
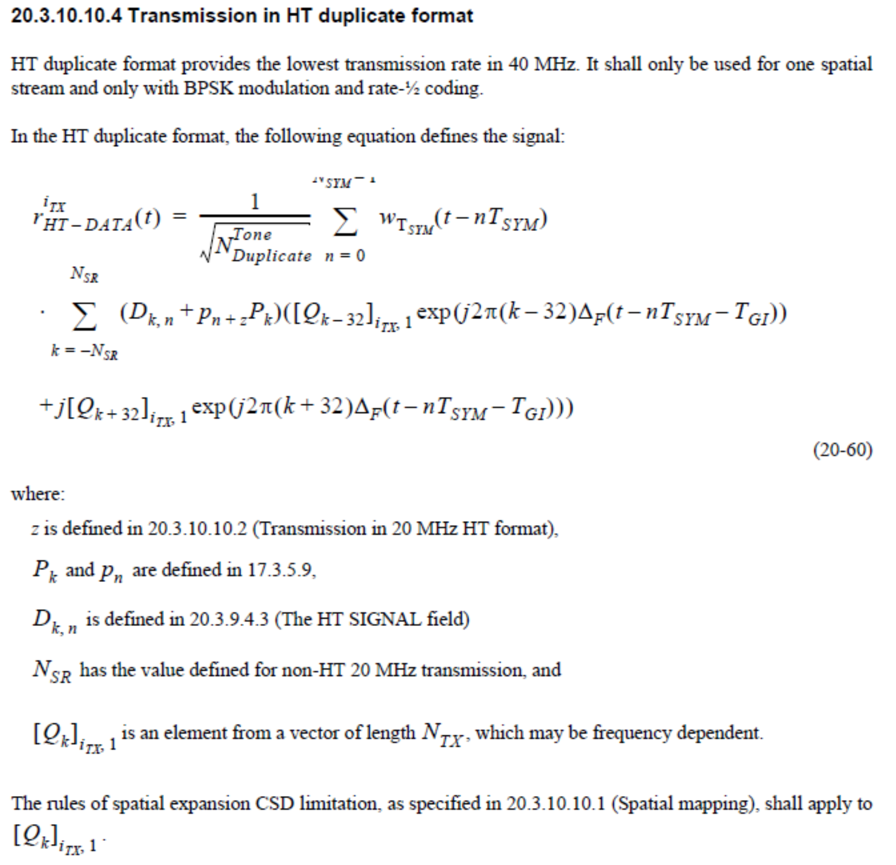
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P_{(i_{STS}, n)}^{k}) \Upsilon_k \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (20-59) where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

Claim 22 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM})$ $\cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n}+p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}))$ $+j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

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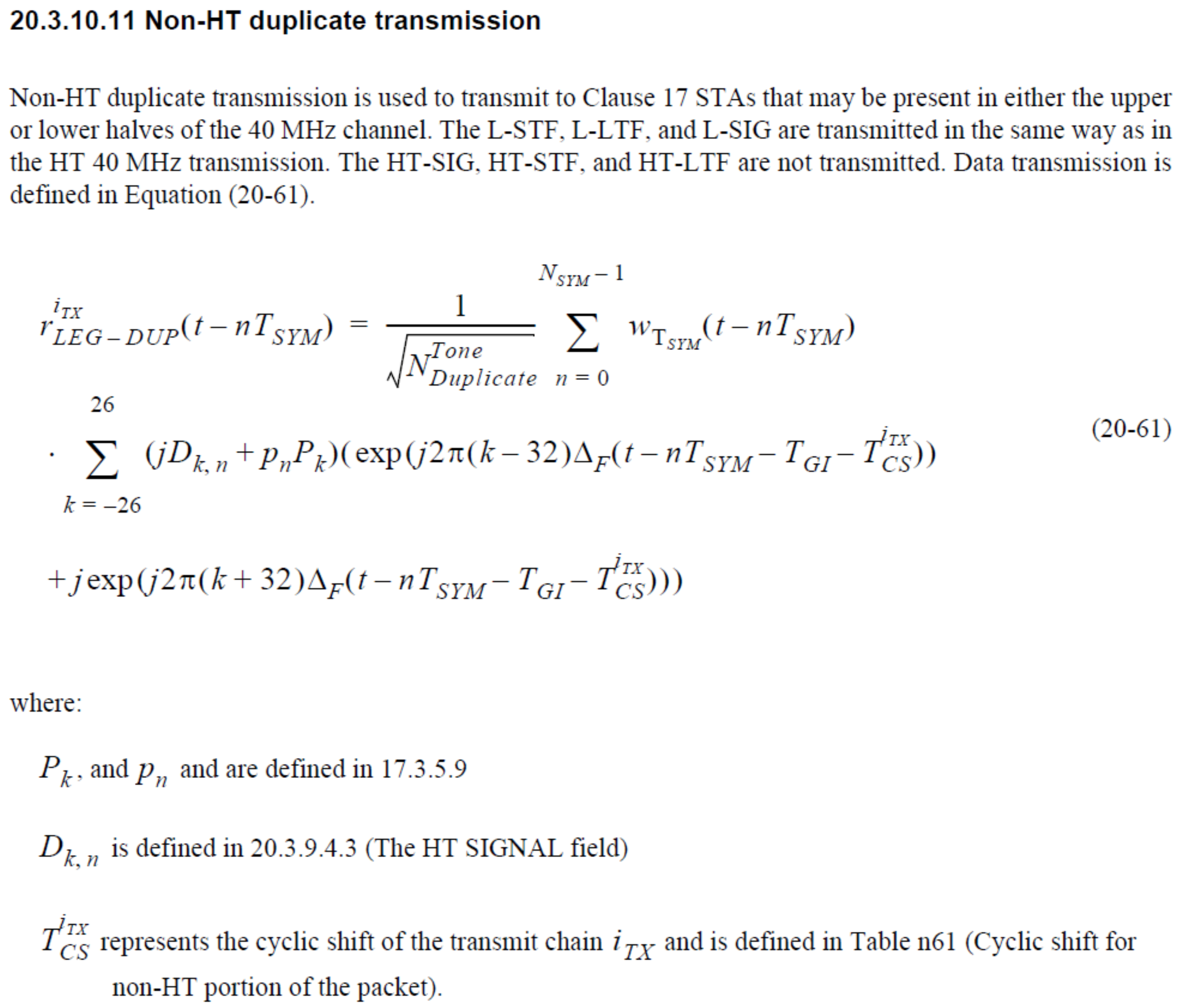
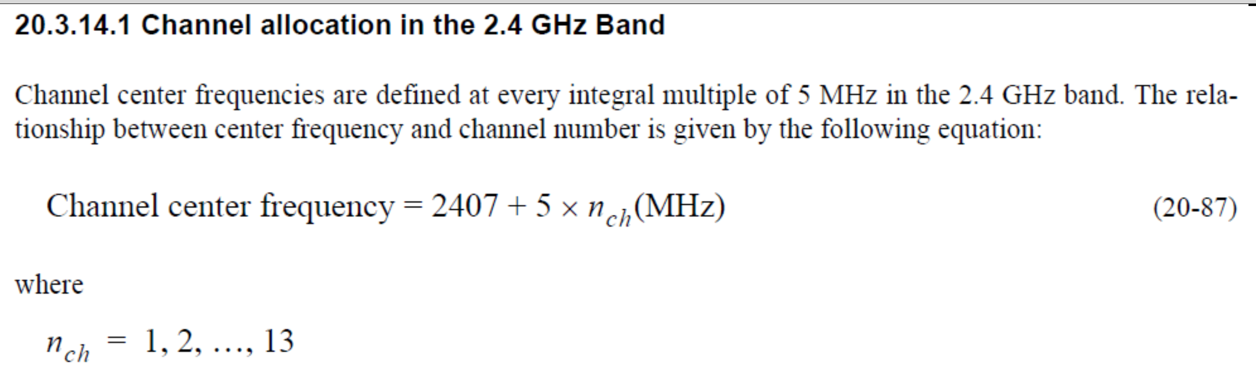
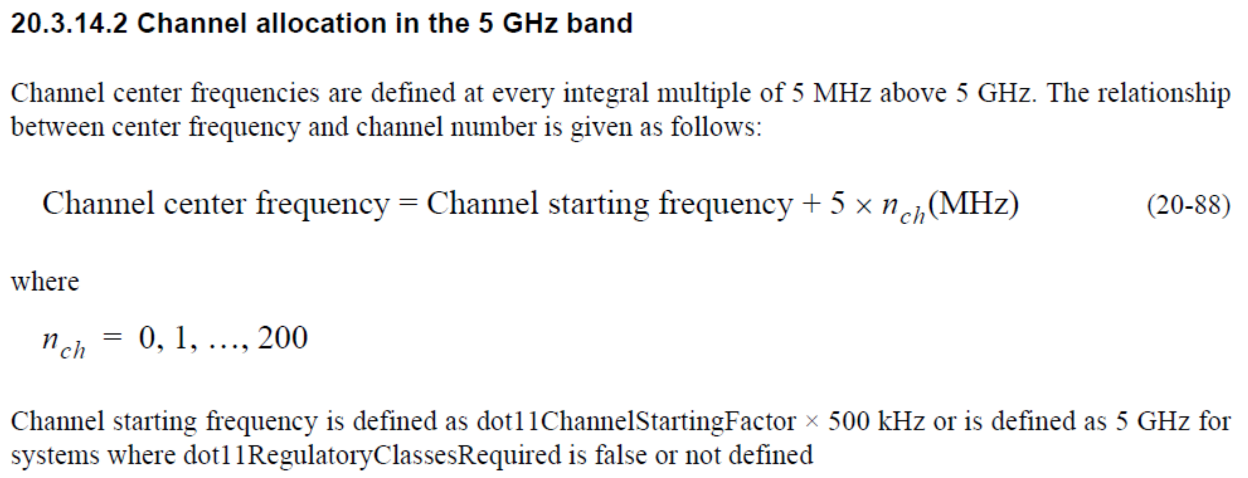
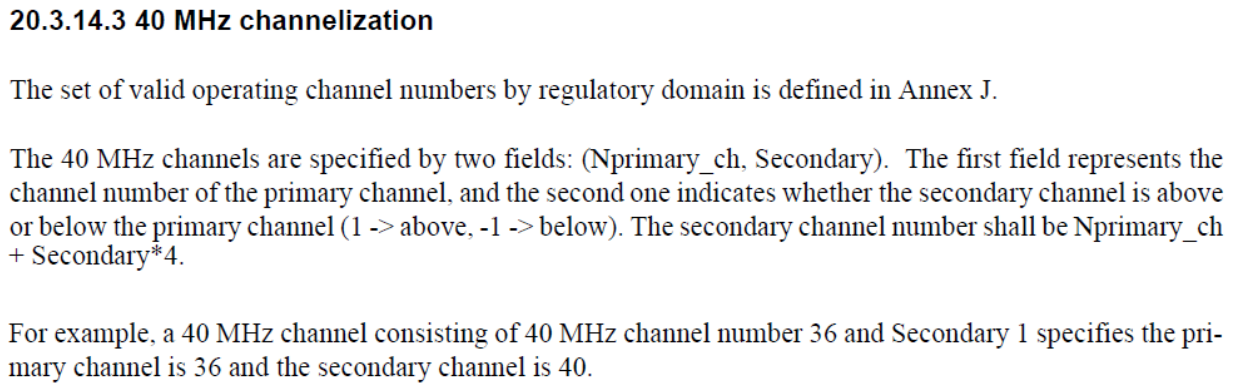
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r^{i_{TX}}_{LEG-DUP}(t - nT_{SYM}) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n} + p_n P_k)(\exp(j2\pi(k-32)\Delta_F(t - nT_{SYM} - T_{GI} - T^{i_{TX}}_{CS})) + j\exp(j2\pi(k+32)\Delta_F(t - nT_{SYM} - T_{GI} - T^{i_{TX}}_{CS})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T^{i_{TX}}_{CS}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 22 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch} (\text{MHz}) \quad (20\text{-}87)$ where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch} (\text{MHz}) \quad (20\text{-}88)$ where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 22 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

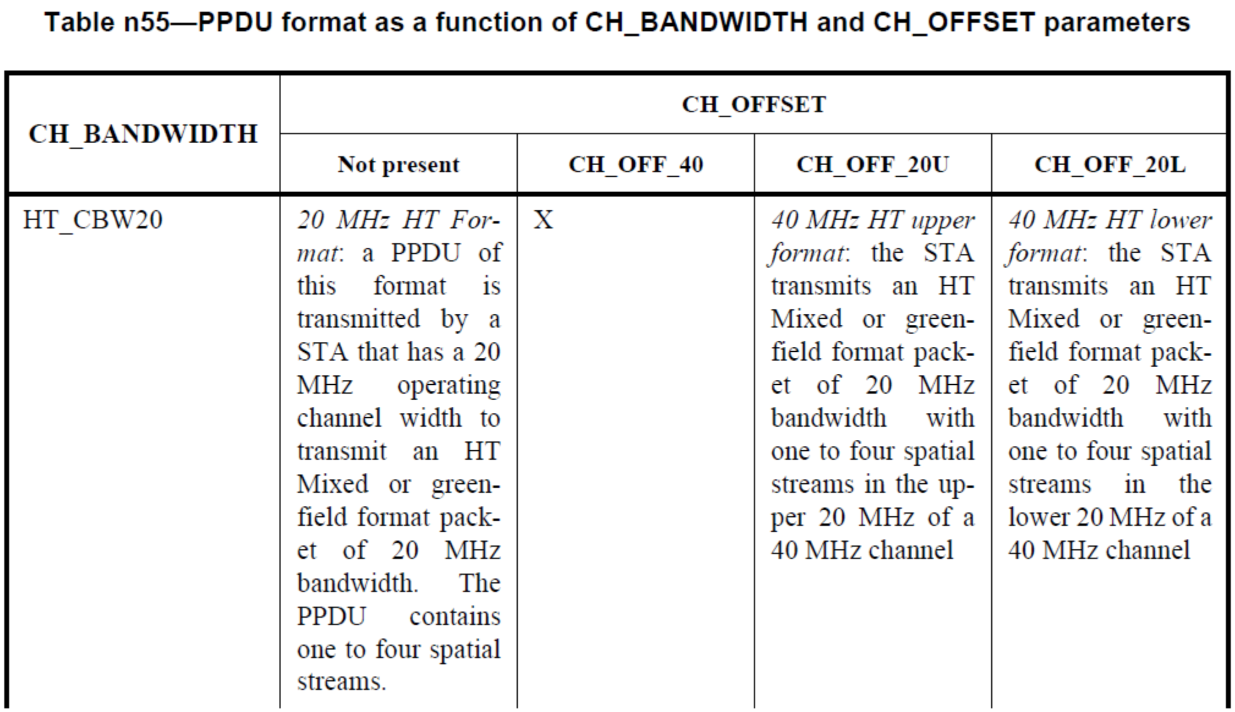
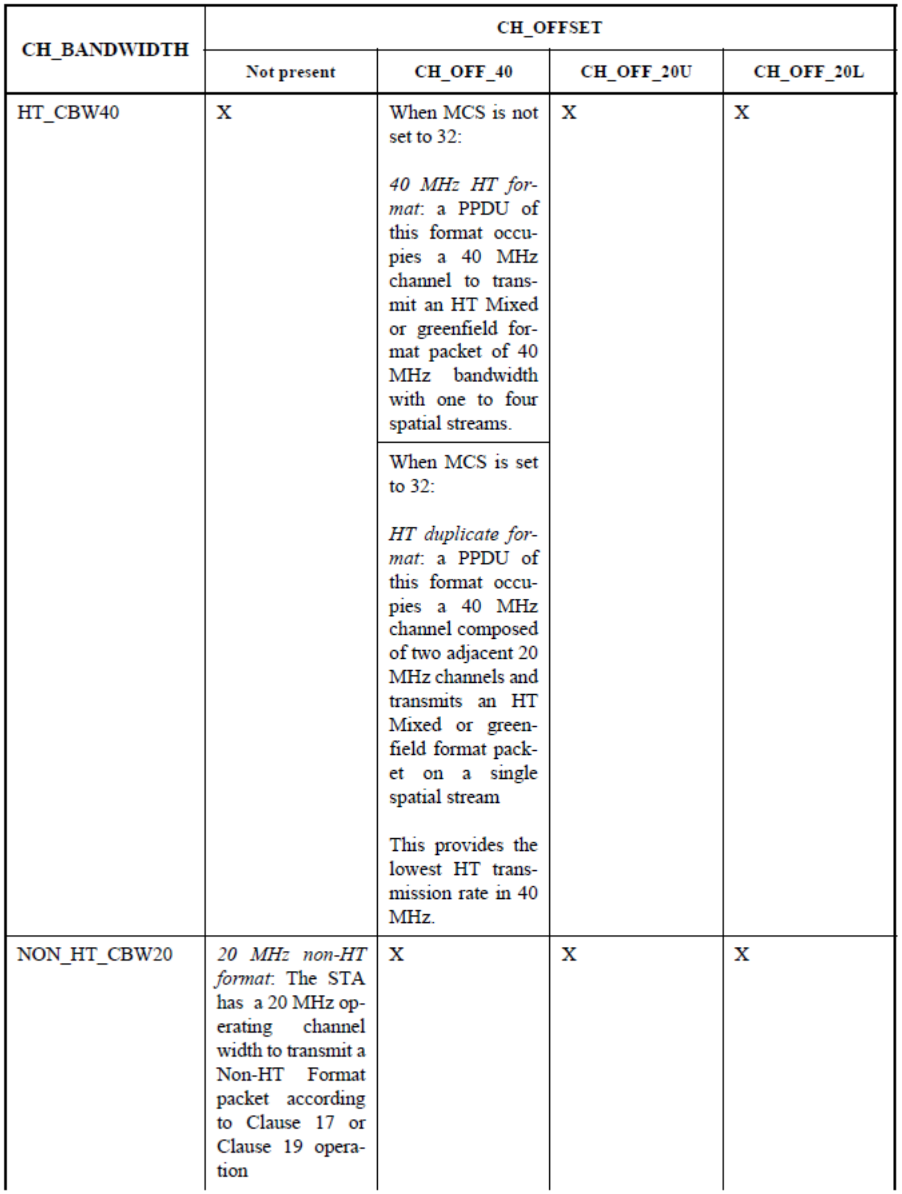
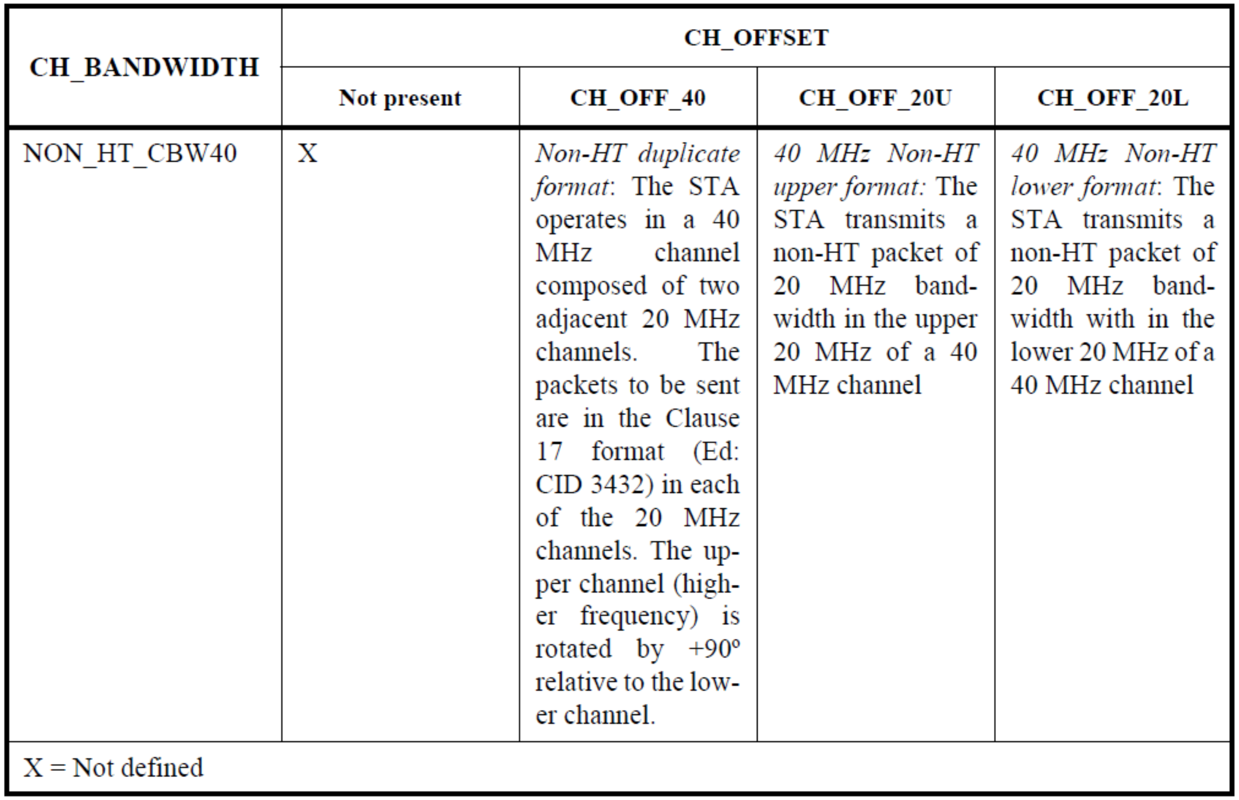
Claim 22 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.20.3 

Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

CH_BANDWIDTH	**CH_OFFSET**			
	Not present	**CH_OFF_40**	**CH_OFF_20U**	**CH_OFF_20L**
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel



CH_BANDWIDTH	**CH_OFFSET**			
	Not present	**CH_OFF_40**	**CH_OFF_20U**	**CH_OFF_20L**
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

<table>
<tr><th>Claim 22 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>NON_HT_CBW40</td><td>X</td><td><i>Non-HT duplicate format</i>: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.</td><td><i>40 MHz Non-HT upper format:</i> The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel</td><td><i>40 MHz Non-HT lower format</i>: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel</td></tr>
<tr><td colspan="5">X = Not defined</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n55
</td></tr>
</table>

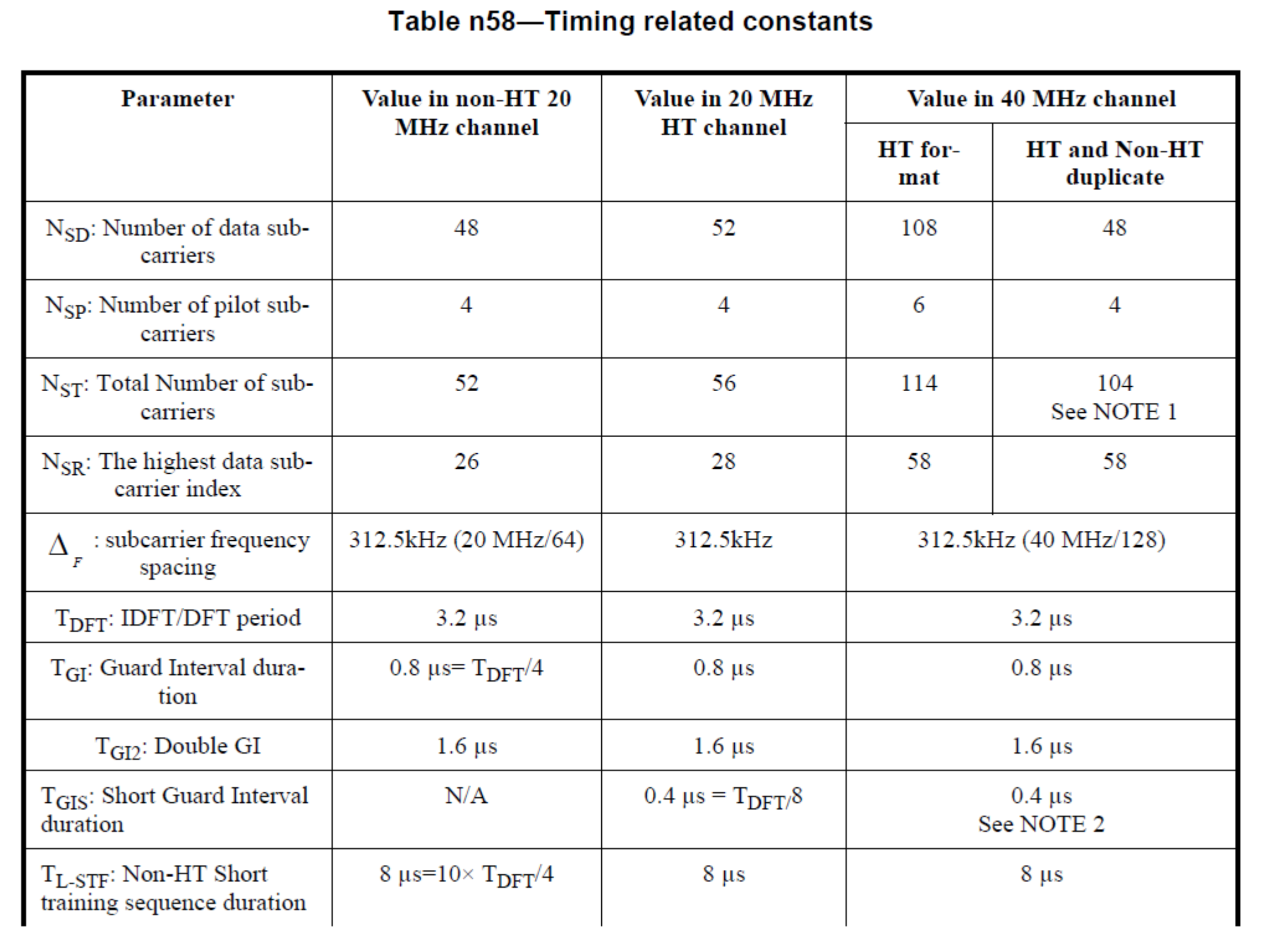
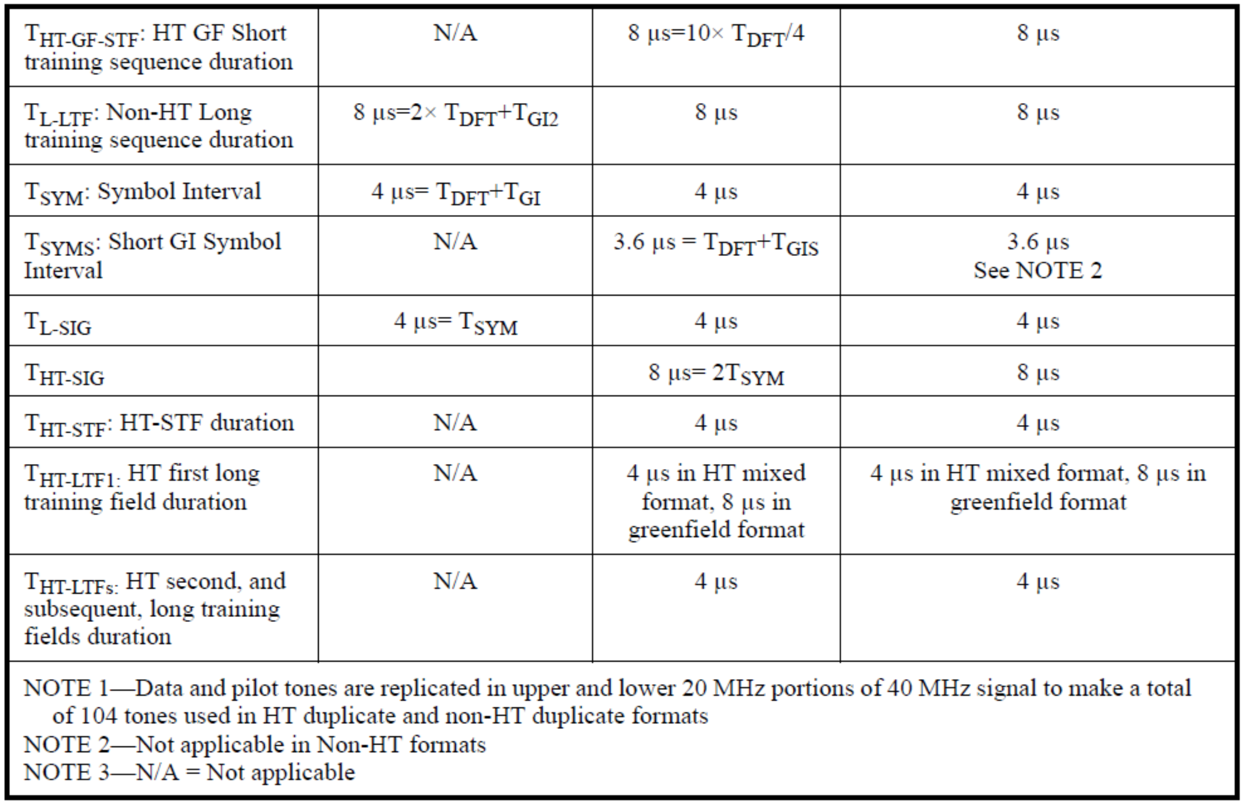
Claim 22 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	

Table n58—Timing related constants

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F: subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
T_{L-STF}: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

Claim 22 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 See, e.g., 802.11n D2.0 Table n58

$T_{HT\text{-}GF\text{-}STF}$: HT GF Short training sequence duration	N/A	8 µs=10× T_{DFT}/4	8 µs
$T_{L\text{-}LTF}$: Non-HT Long training sequence duration	8 µs=2× $T_{DFT}+T_{GI2}$	8 µs	8 µs
T_{SYM}: Symbol Interval	4 µs= $T_{DFT}+T_{GI}$	4 µs	4 µs
T_{SYMS}: Short GI Symbol Interval	N/A	3.6 µs = $T_{DFT}+T_{GIS}$	3.6 µs See NOTE 2
$T_{L\text{-}SIG}$	4 µs= T_{SYM}	4 µs	4 µs
$T_{HT\text{-}SIG}$		8 µs= 2T_{SYM}	8 µs
$T_{HT\text{-}STF}$: HT-STF duration	N/A	4 µs	4 µs
$T_{HT\text{-}LTF1}$: HT first long training field duration	N/A	4 µs in HT mixed format, 8 µs in greenfield format	4 µs in HT mixed format, 8 µs in greenfield format
$T_{HT\text{-}LTFs}$: HT second, and subsequent, long training fields duration	N/A	4 µs	4 µs

NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable

<table>
<tr><th>Claim 22 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

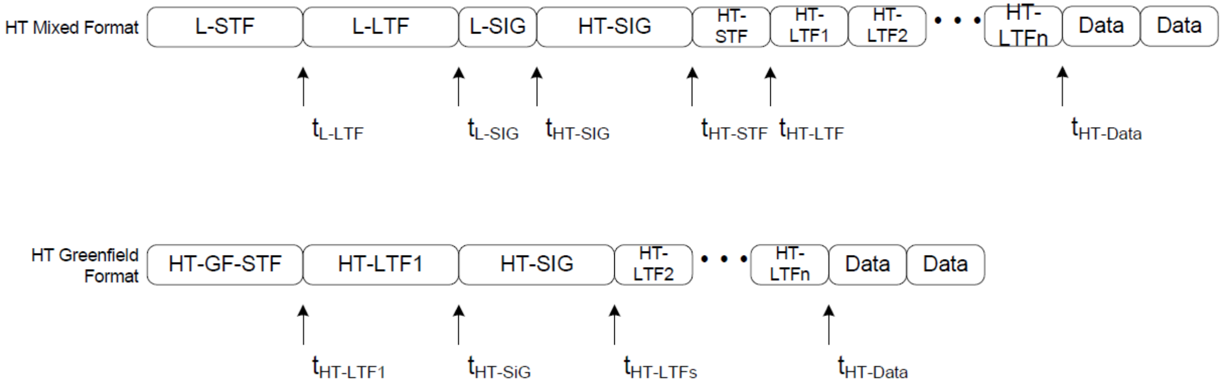


Figure n65—Timing boundaries for PPDU fields

See, e.g., 802.11n D2.0 Figure n65

Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.

</td></tr>
</table>

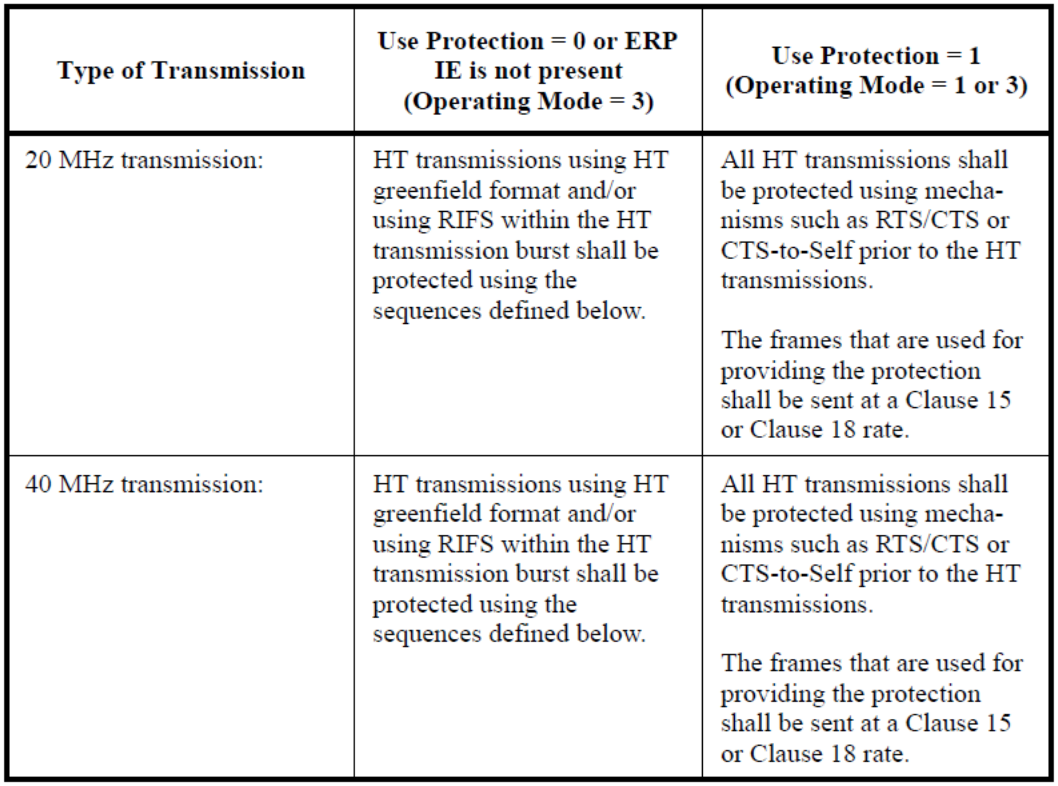
Claim 23 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
[23.1] The communication system of claim 17	802.11n D2.0 discloses all the elements of claim 17 for all the reasons provided above.
[23.2] wherein first and second data to be transmitted	802.11n D2.0 discloses “wherein first and second data to be transmitted comprise a plurality of OFDM symbols, wherein a first symbol is transmitted during a first time slot across the first up-

Claim 23 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
comprise a plurality of OFDM symbols, wherein a first symbol is transmitted during a first time slot across the first up-converted frequency range and a second symbol is transmitted during the first time slot across the second up-converted frequency range, and wherein a third symbol is transmitted during a second time slot across the first up-converted frequency range and a fourth symbol is transmitted during the second time slot across a second up-converted frequency range.	converted frequency range and a second symbol is transmitted during the first time slot across the second up-converted frequency range, and wherein a third symbol is transmitted during a second time slot across the first up-converted frequency range and a fourth symbol is transmitted during the second time slot across a second up-converted frequency range.” See, e.g.: **high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19 **non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

Claim 23 of the ’802 Patent	Prior Art Reference – 802.11n D2.0

When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

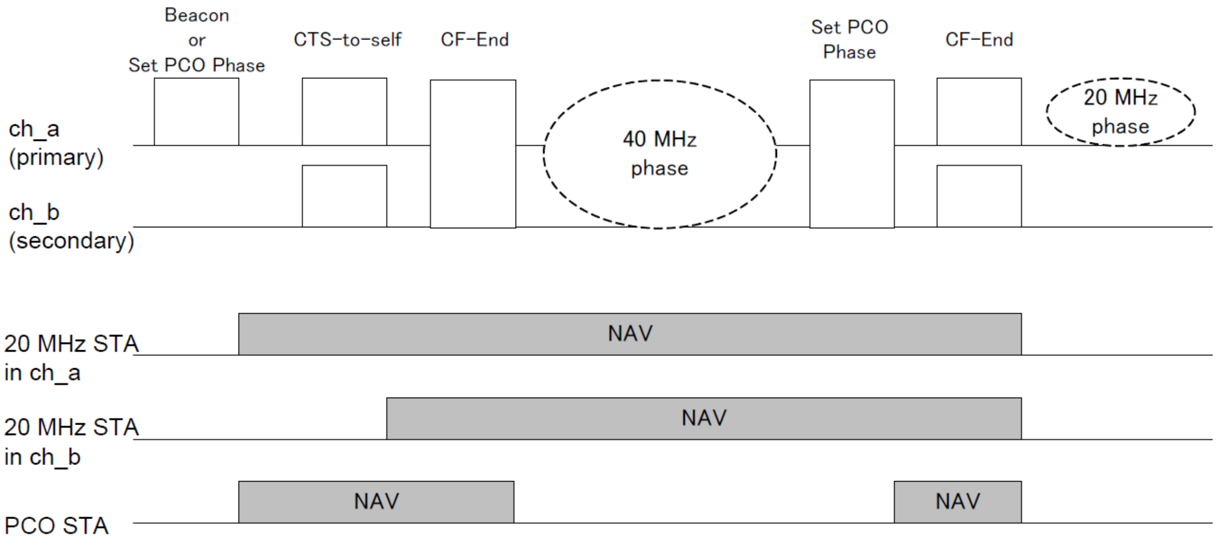
Table n49—Protection requirements for Operating Modes of 1 and 3



Type of Transmission	Use Protection = 0 or ERP IE is not present (Operating Mode = 3)	Use Protection = 1 (Operating Mode = 1 or 3)
20 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.
40 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:

Claim 23 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions: 1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19 2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20. NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames). b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

Claim 23 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

Claim 23 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 23 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

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	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

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	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

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	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t \right) \right\}$ (20-1) where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

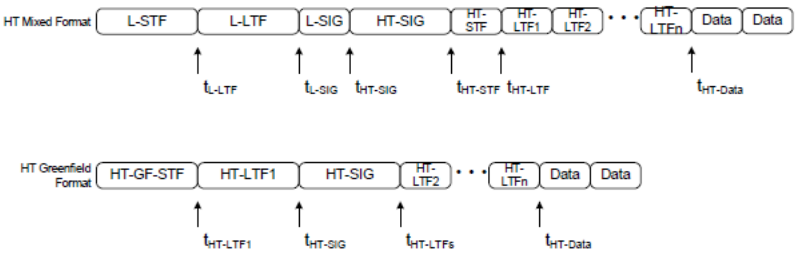

Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t-t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t-t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t-t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t-t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t-t_{HT-LTF}-\left(i_{LTF}-1\right)T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}\left(t-t_{HT-DATA}\right) \end{aligned} \tag{20-2}$$

where

$$t_{L-LTF} = T_{L-STF}$$

$$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$$

$$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$$

$$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$r_{PPDU}^{(i_{TX})}(t) = r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1})$$

$$+ r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG})$$

$$+ \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2)T_{HT-LTFs})$$

$$+ r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \qquad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\text{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\text{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j2\pi k \Delta_F t) \qquad (20\text{-}4)$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \qquad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \qquad (20\text{-}6)$$

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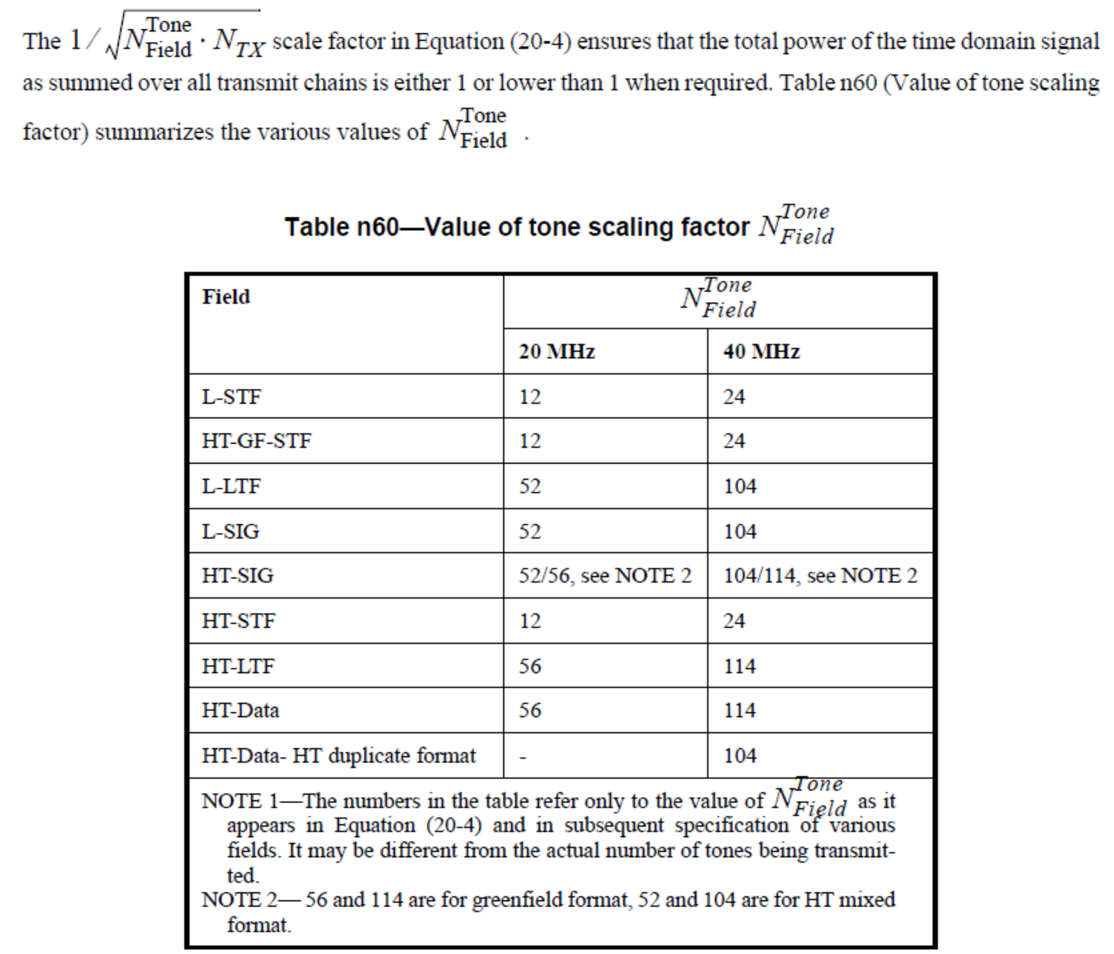

The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	**40 MHz**
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

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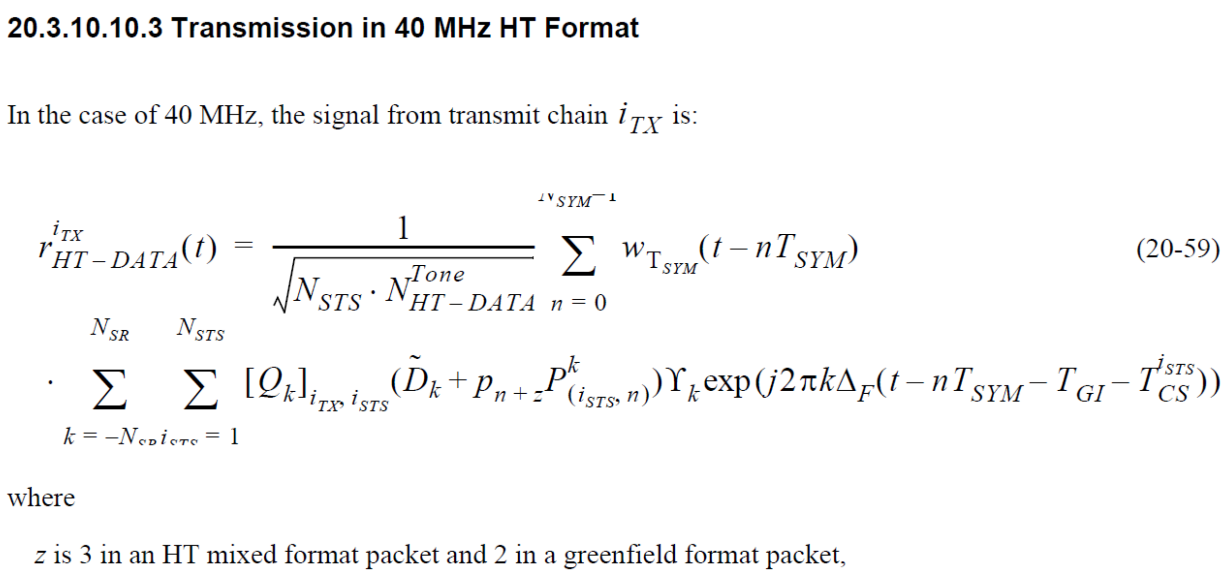
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS} \cdot N^{Tone}_{HT-DATA}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P^k_{(i_{STS},n)}) \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T^{i_{STS}}_{CS}))$ (20-58) where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

Claim 23 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS}\cdot N^{Tone}_{HT-DATA}}}\sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}}\sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX},i_{STS}}(\tilde{D}_k + p_{n+z}P^k_{(i_{STS},n)})\Upsilon_k \exp(j2\pi k\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{STS}}_{CS}))$ (20-59) where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

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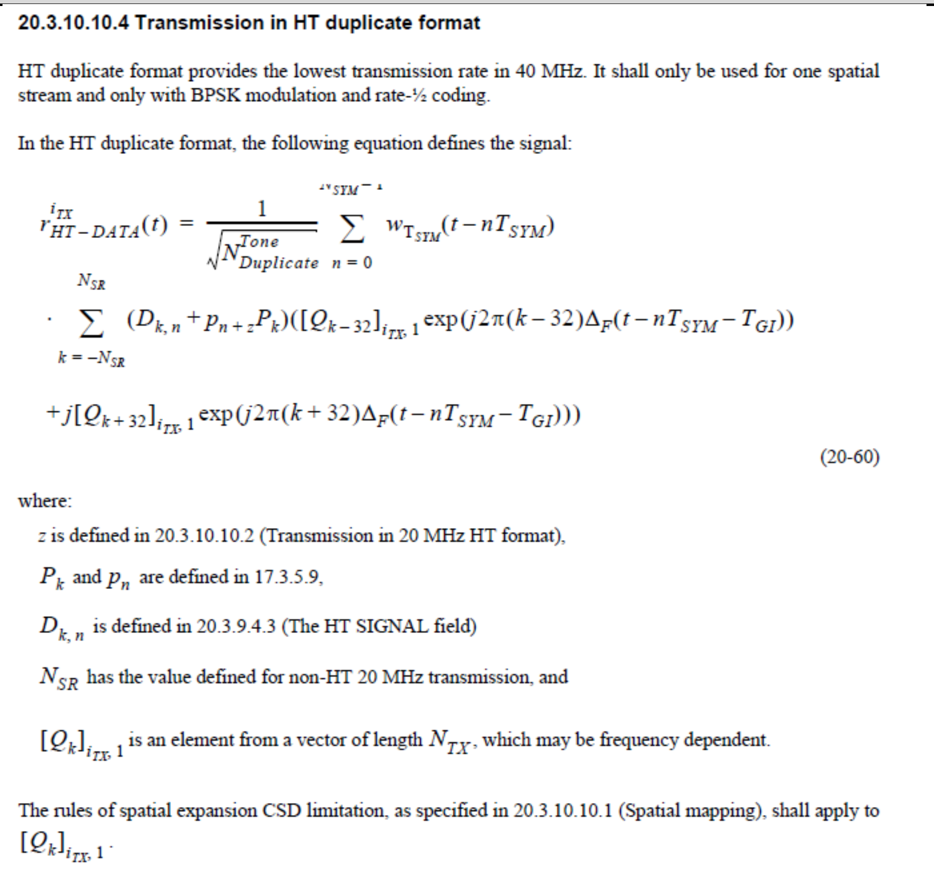
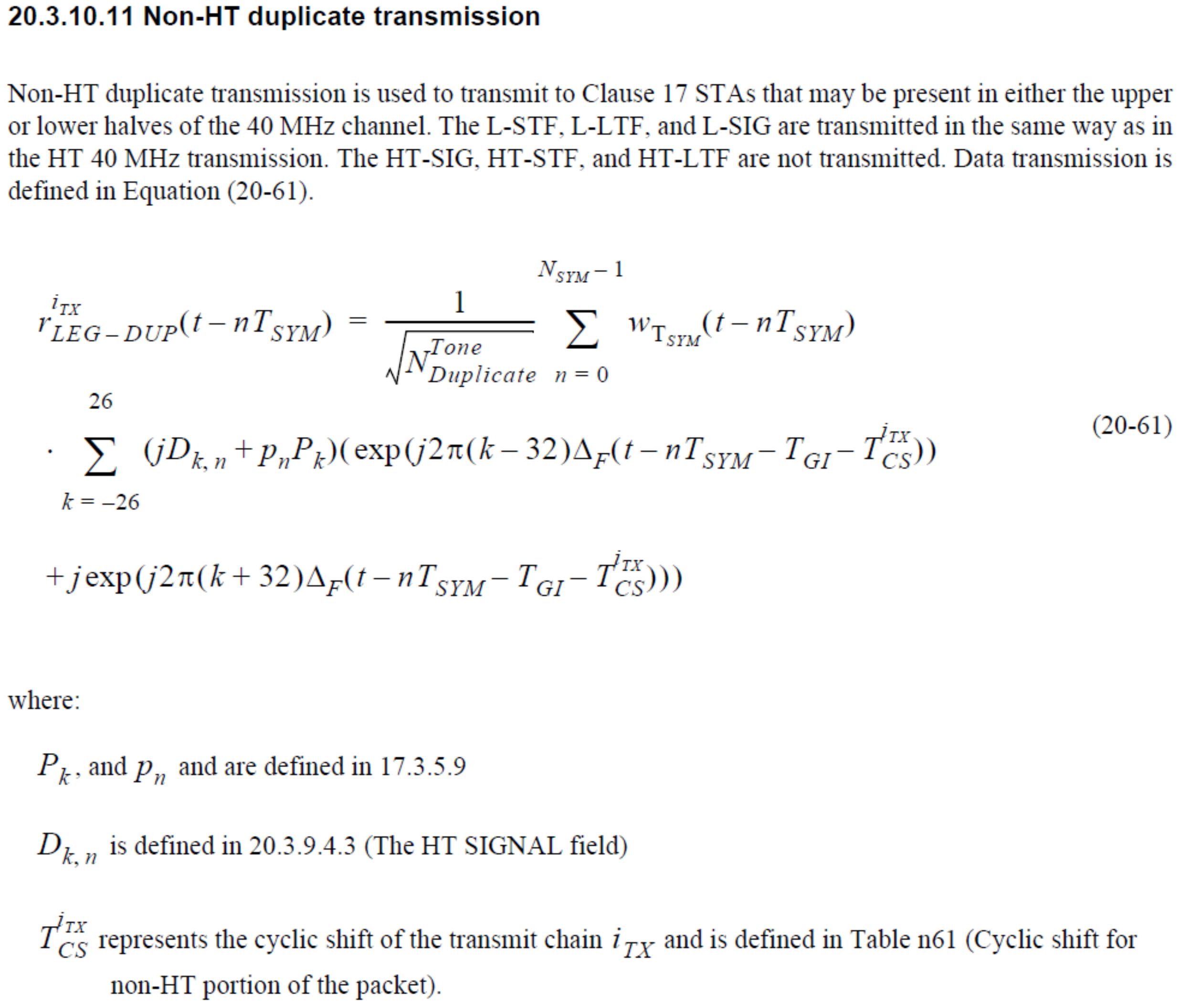
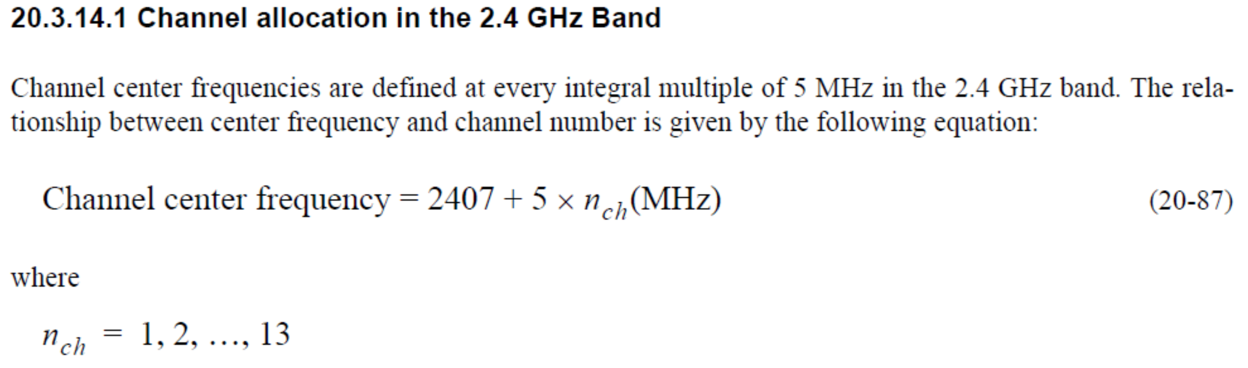
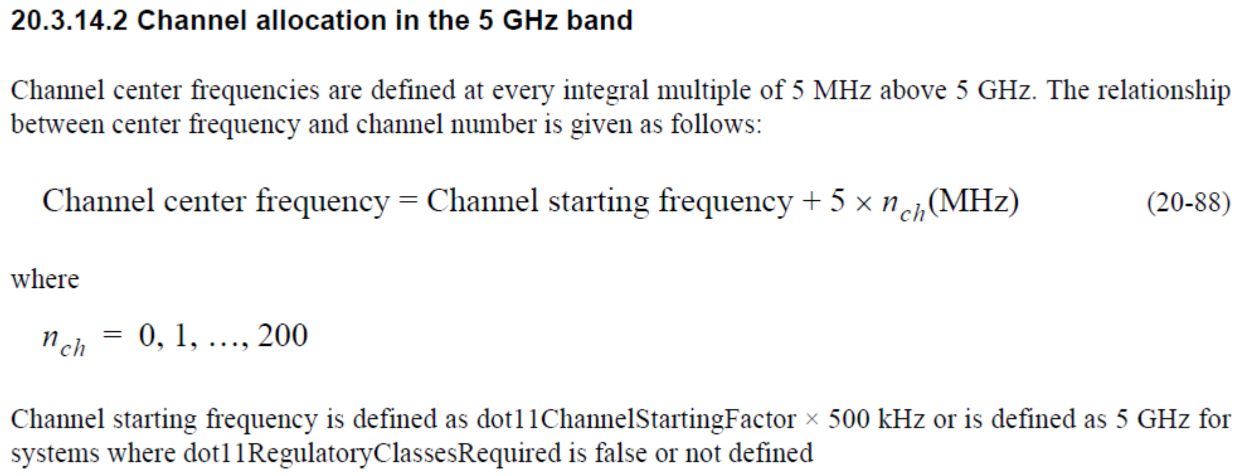
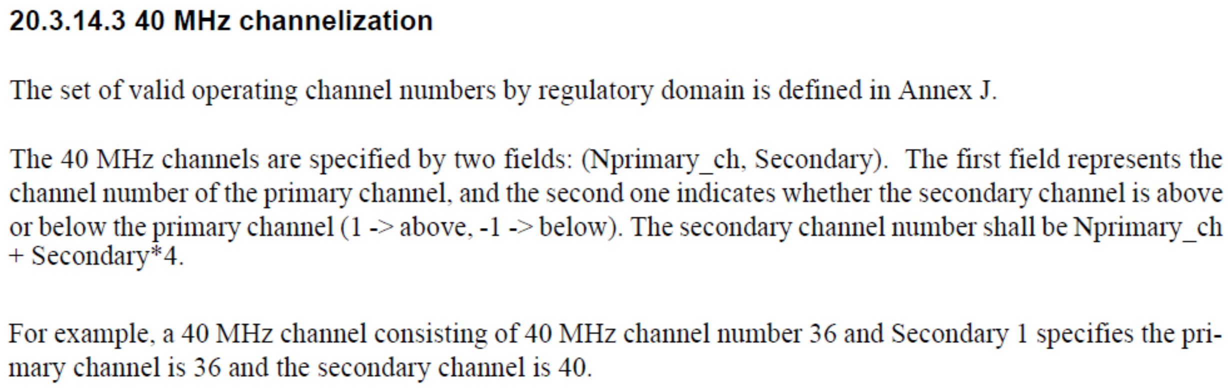
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n}+p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1}\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI})) + j[Q_{k+32}]_{i_{TX},1}\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

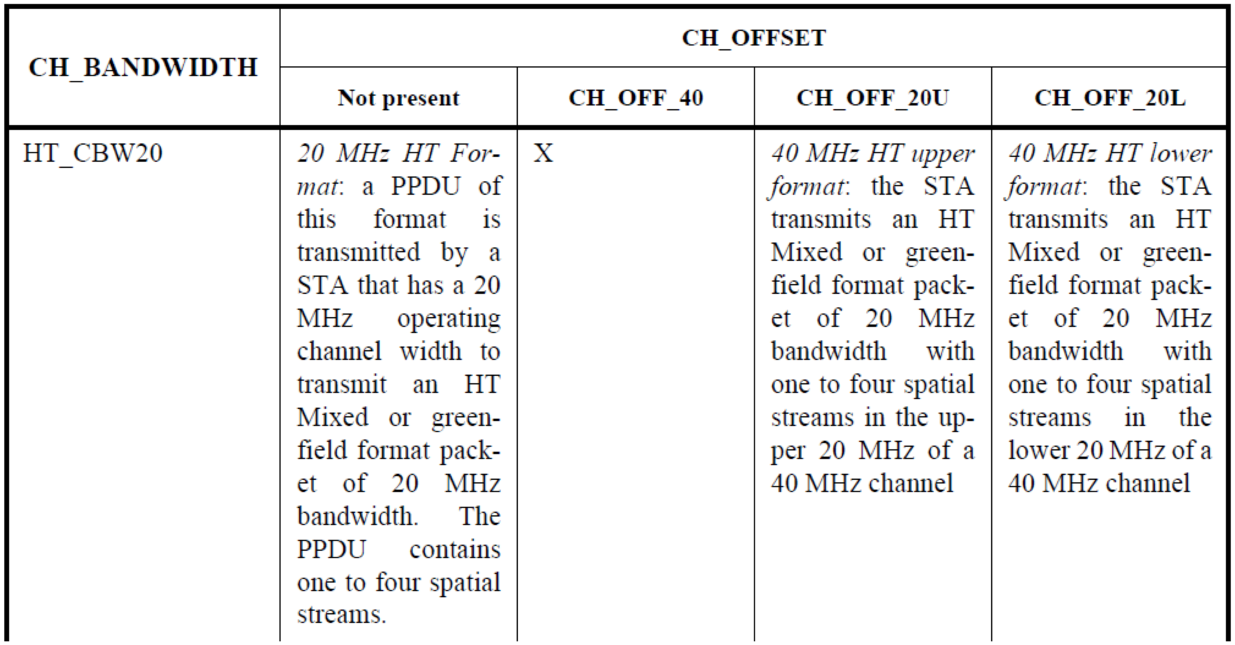
Claim 23 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $$r^{i_{TX}}_{LEG-DUP}(t - nT_{SYM}) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n} + p_n P_k)(\exp(j2\pi(k-32)\Delta_F(t - nT_{SYM} - T_{GI} - T^{i_{TX}}_{CS})) + j\exp(j2\pi(k+32)\Delta_F(t - nT_{SYM} - T_{GI} - T^{i_{TX}}_{CS}))) \quad (20\text{-}61)$$ where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T^{i_{TX}}_{CS}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 23 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz})$ (20-87) where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz})$ (20-88) where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

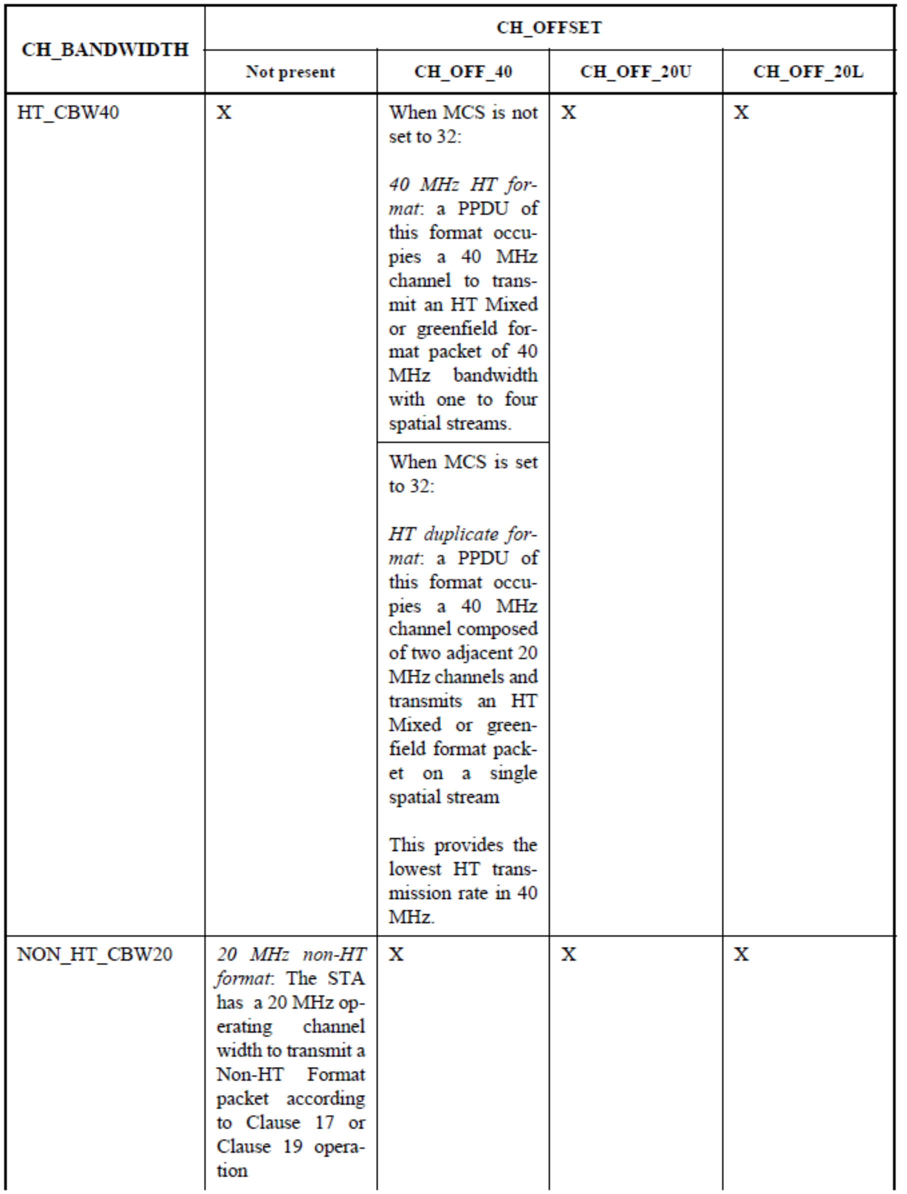
Claim 23 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

<table>
<tr><th>Claim 23 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>
See, e.g., 802.11n D2.0 § 20.3.20.3

Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

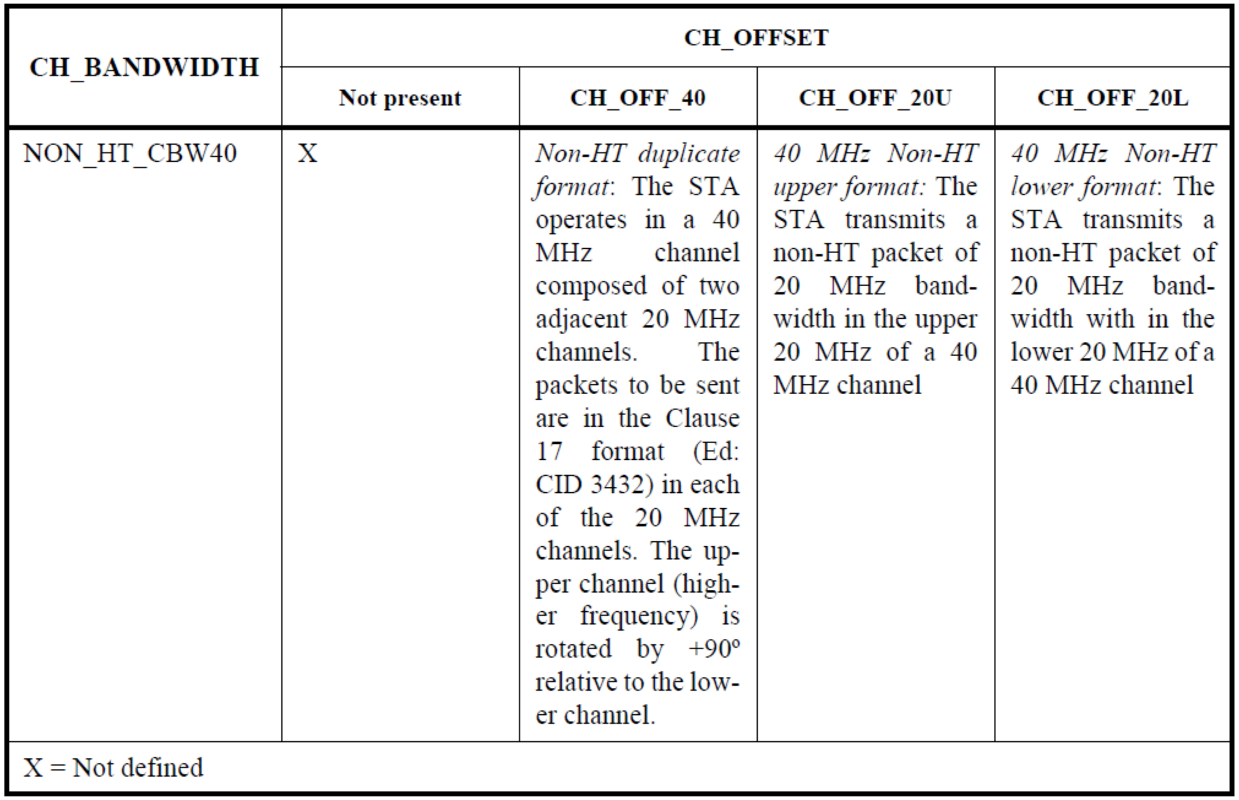


<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>HT_CBW20</td><td><i>20 MHz HT Format</i>: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.</td><td>X</td><td><i>40 MHz HT upper format</i>: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel</td><td><i>40 MHz HT lower format</i>: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel</td></tr>
</table>
</td></tr>
</table>



CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

Claim 23 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**



CH_BANDWIDTH	**CH_OFFSET**			
	Not present	**CH_OFF_40**	**CH_OFF_20U**	**CH_OFF_20L**
NON_HT_CBW40	X	*Non-HT duplicate format*: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.	*40 MHz Non-HT upper format:* The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel	*40 MHz Non-HT lower format*: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel

X = Not defined

See, e.g., 802.11n D2.0 Table n55

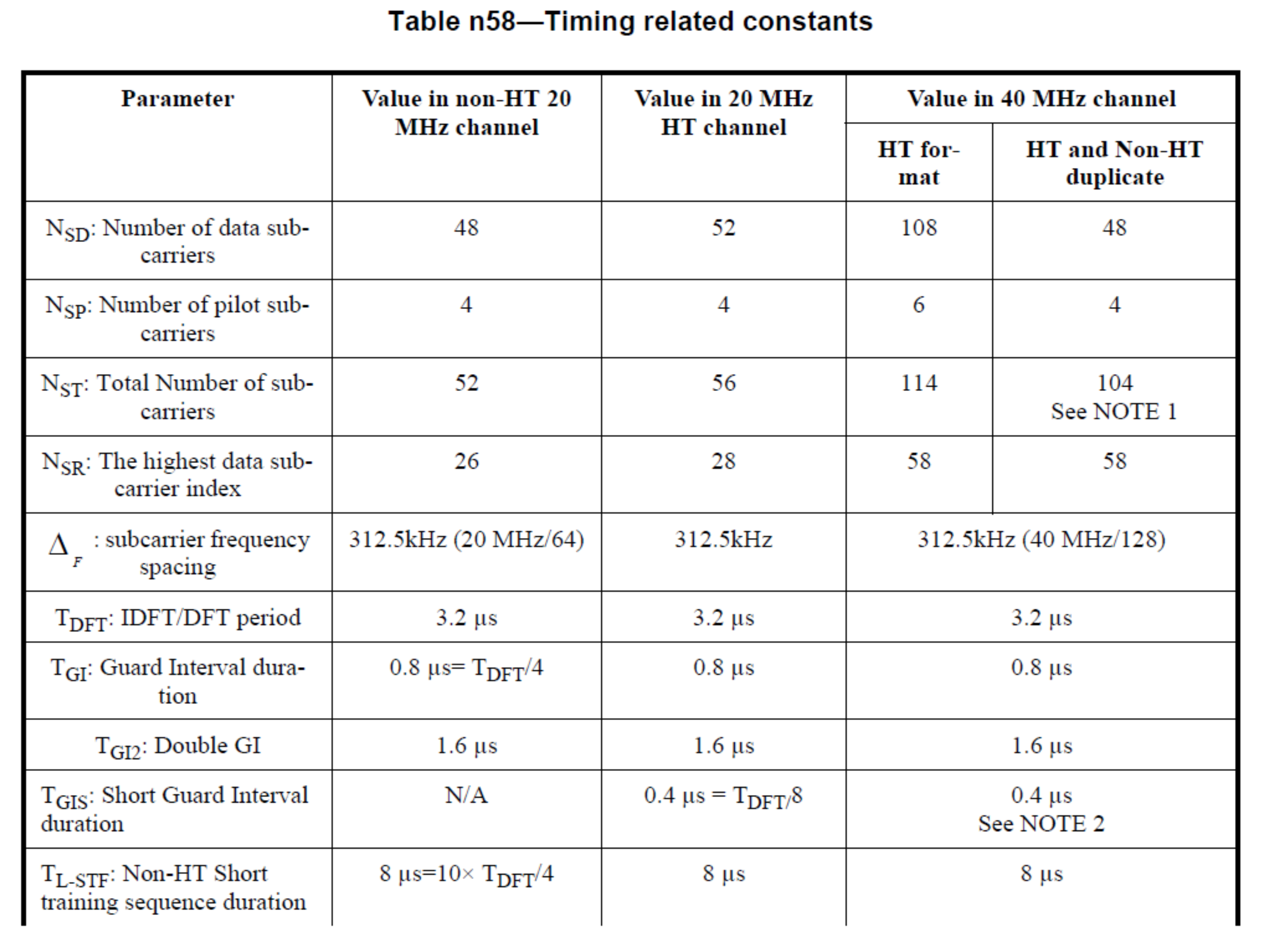
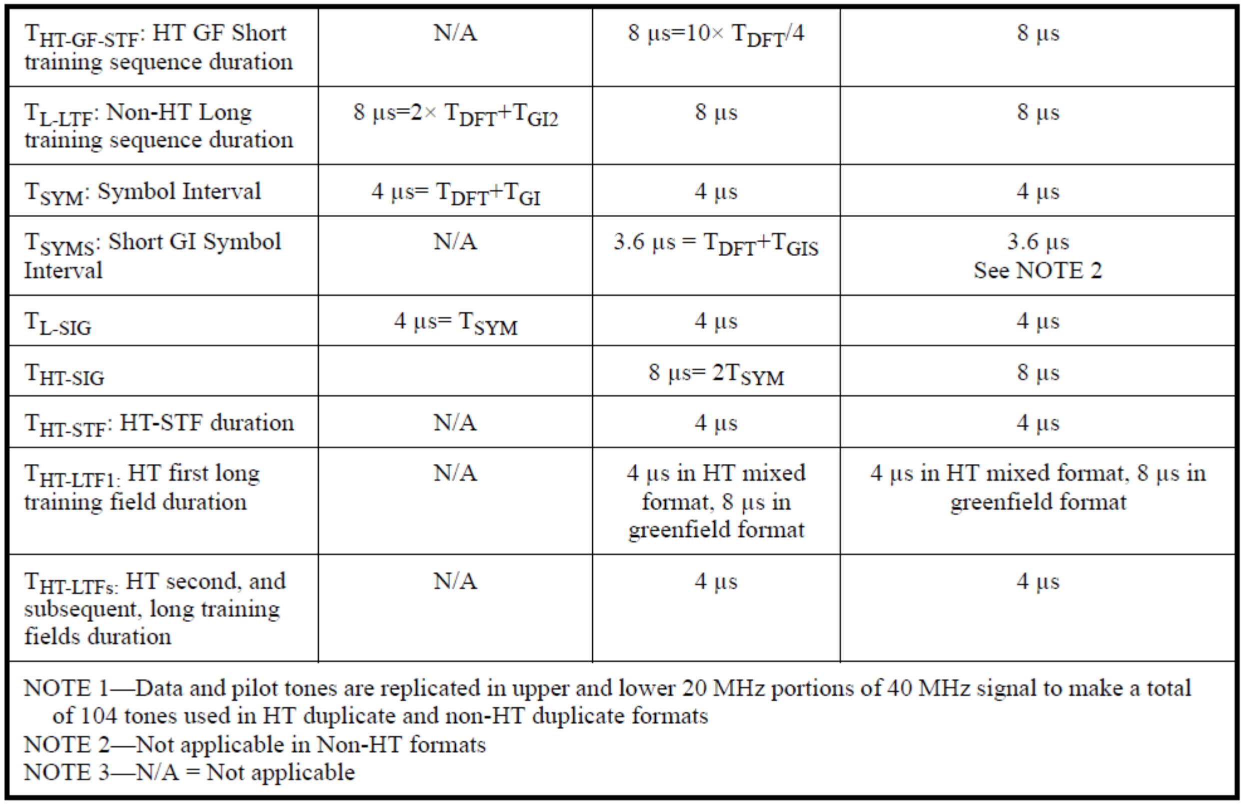
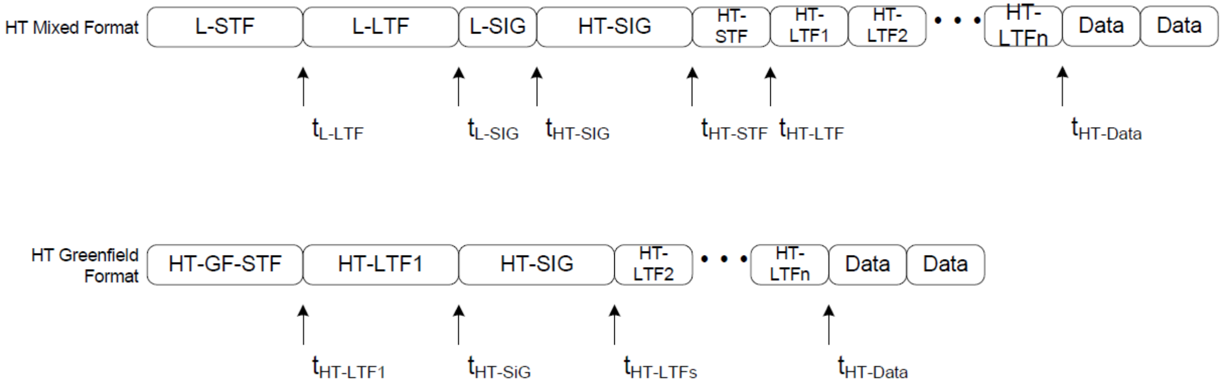
Claim 23 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	

Table n58—Timing related constants

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

<table>
<tr><th>Claim 23 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><td>$T_{HT\text{-}GF\text{-}STF}$: HT GF Short training sequence duration</td><td>N/A</td><td>8 µs=10× $T_{DFT}/4$</td><td>8 µs</td></tr>
<tr><td>$T_{L\text{-}LTF}$: Non-HT Long training sequence duration</td><td>8 µs=2× $T_{DFT}+T_{GI2}$</td><td>8 µs</td><td>8 µs</td></tr>
<tr><td>T_{SYM}: Symbol Interval</td><td>4 µs= $T_{DFT}+T_{GI}$</td><td>4 µs</td><td>4 µs</td></tr>
<tr><td>T_{SYMS}: Short GI Symbol Interval</td><td>N/A</td><td>3.6 µs = $T_{DFT}+T_{GIS}$</td><td>3.6 µs
See NOTE 2</td></tr>
<tr><td>$T_{L\text{-}SIG}$</td><td>4 µs= T_{SYM}</td><td>4 µs</td><td>4 µs</td></tr>
<tr><td>$T_{HT\text{-}SIG}$</td><td></td><td>8 µs= $2T_{SYM}$</td><td>8 µs</td></tr>
<tr><td>$T_{HT\text{-}STF}$: HT-STF duration</td><td>N/A</td><td>4 µs</td><td>4 µs</td></tr>
<tr><td>$T_{HT\text{-}LTF1}$: HT first long training field duration</td><td>N/A</td><td>4 µs in HT mixed format, 8 µs in greenfield format</td><td>4 µs in HT mixed format, 8 µs in greenfield format</td></tr>
<tr><td>$T_{HT\text{-}LTFs}$: HT second, and subsequent, long training fields duration</td><td>N/A</td><td>4 µs</td><td>4 µs</td></tr>
<tr><td colspan="4">NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n58
</td></tr>
</table>

Claim 23 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.

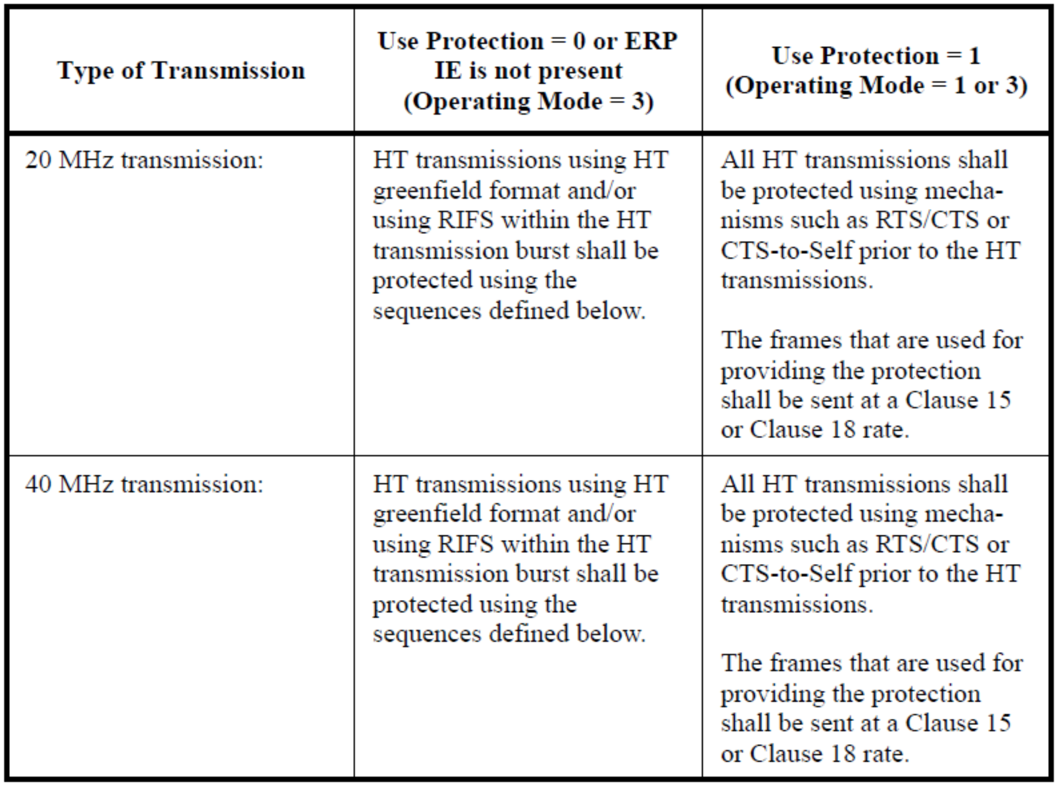
Claim 24 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
[24.1] An electronic circuit comprising:	To the extent the preamble is limiting, 802.11n D2.0 discloses “An electronic circuit comprising.” Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-

Claim 24 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.
[24.2] a first down-converter circuit having a first input coupled to receive a first up-converted signal, a second input coupled to receive a first demodulation signal having a first RF frequency, and an output, wherein the first down-converter circuit outputs a first down-converted signal on the first down-converter output;	802.11n D2.0 discloses “a first down-converter circuit having a first input coupled to receive a first up-converted signal, a second input coupled to receive a first demodulation signal having a first RF frequency, and an output, wherein the first down-converter circuit outputs a first down-converted signal on the first down-converter output.” See, e.g.: **high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19 **non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0.

Claim 24 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

<table>
<tr><th>Claim 24 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

Table n49—Protection requirements for Operating Modes of 1 and 3

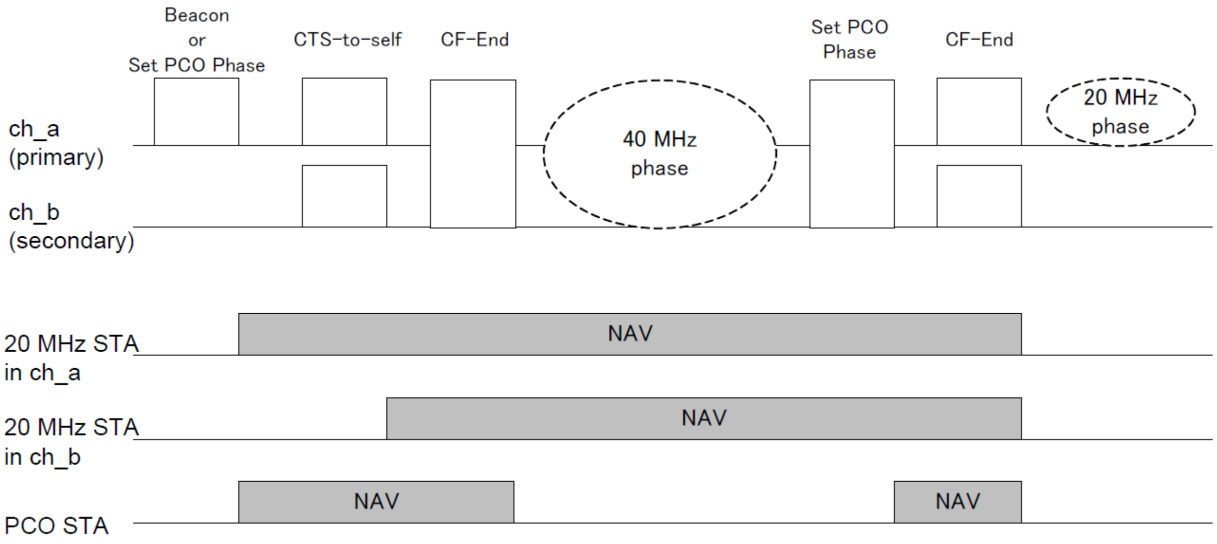


<table>
<tr><th>Type of Transmission</th><th>Use Protection = 0 or ERP IE is not present (Operating Mode = 3)</th><th>Use Protection = 1 (Operating Mode = 1 or 3)</th></tr>
<tr><td>20 MHz transmission:</td><td>HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.</td><td>All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions.
The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.</td></tr>
<tr><td>40 MHz transmission:</td><td>HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.</td><td>All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions.
The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.</td></tr>
</table>

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.
NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).

</td></tr>
</table>

Claim 24 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

Claim 24 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

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	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

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	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

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	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t \right) \right\} \qquad (20\text{-}1)$ where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

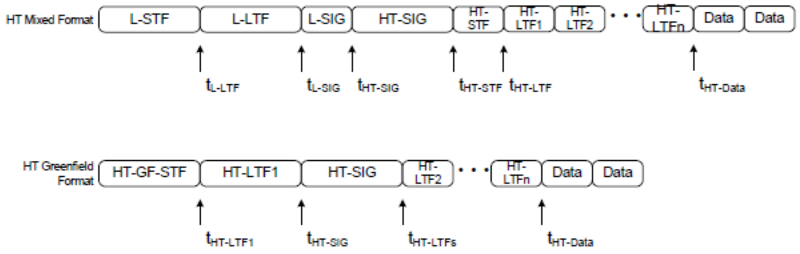

Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) \;=\; & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right) T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}\left(t - t_{HT-DATA}\right) \end{aligned} \tag{20-2}$$

where

$$t_{L-LTF} = T_{L-STF}$$

$$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$$

$$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$$

$$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1}) \\ & + r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2)T_{HT-LTFs}) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \quad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\mathrm{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\mathrm{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\mathrm{Field}}^{\mathrm{Tone}} \cdot N_{TX}}} w_{T_{\mathrm{Field}}}(t) \sum_k \Upsilon_k X_k^{(i_{TX})} \exp(j 2\pi k \Delta_F t) \quad (20\text{-}4)$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\mathrm{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \quad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \quad (20\text{-}6)$$

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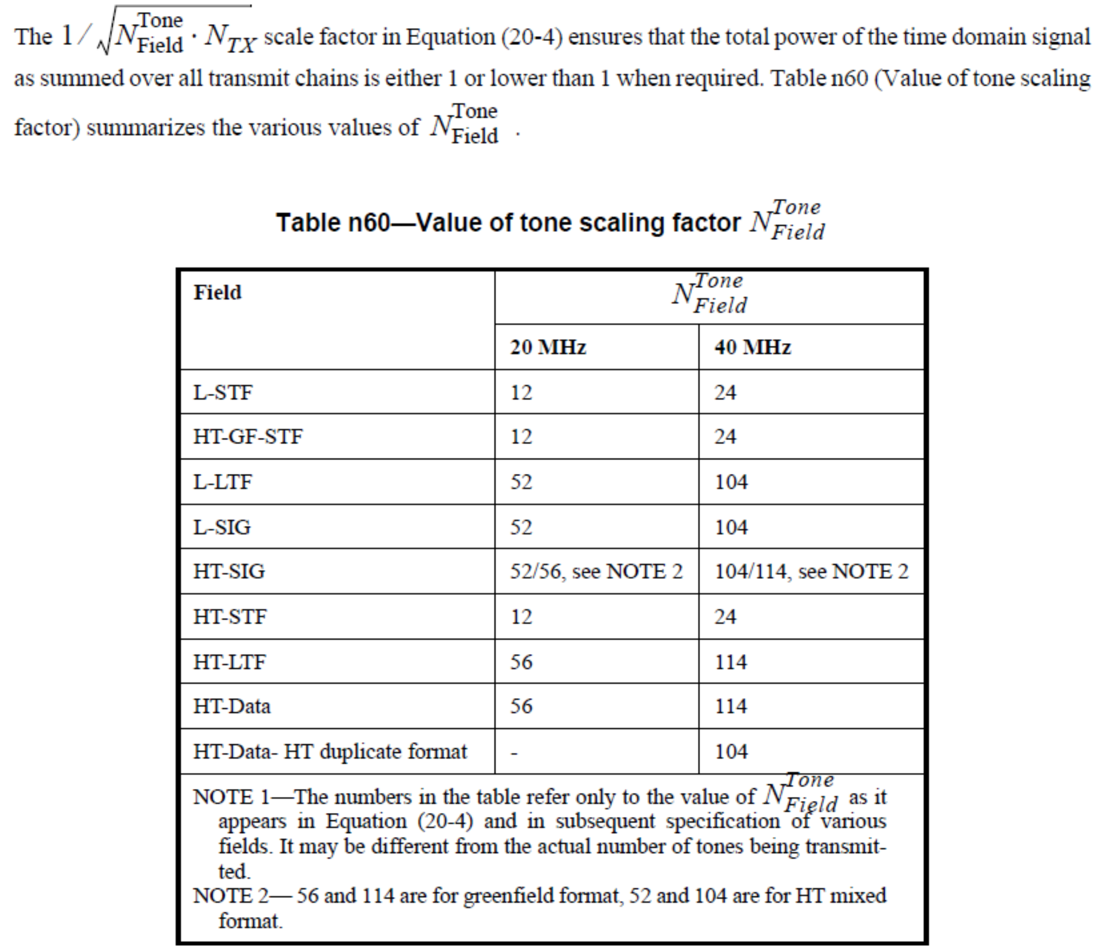

The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	**40 MHz**
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

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	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $$D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k), n}, \text{ otherwise} \end{cases}$$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $$r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS} \cdot N^{Tone}_{HT-DATA}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P^k_{(i_{STS}, n)}) \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T^{i_{STS}}_{CS})) \quad (20\text{-}58)$$ where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

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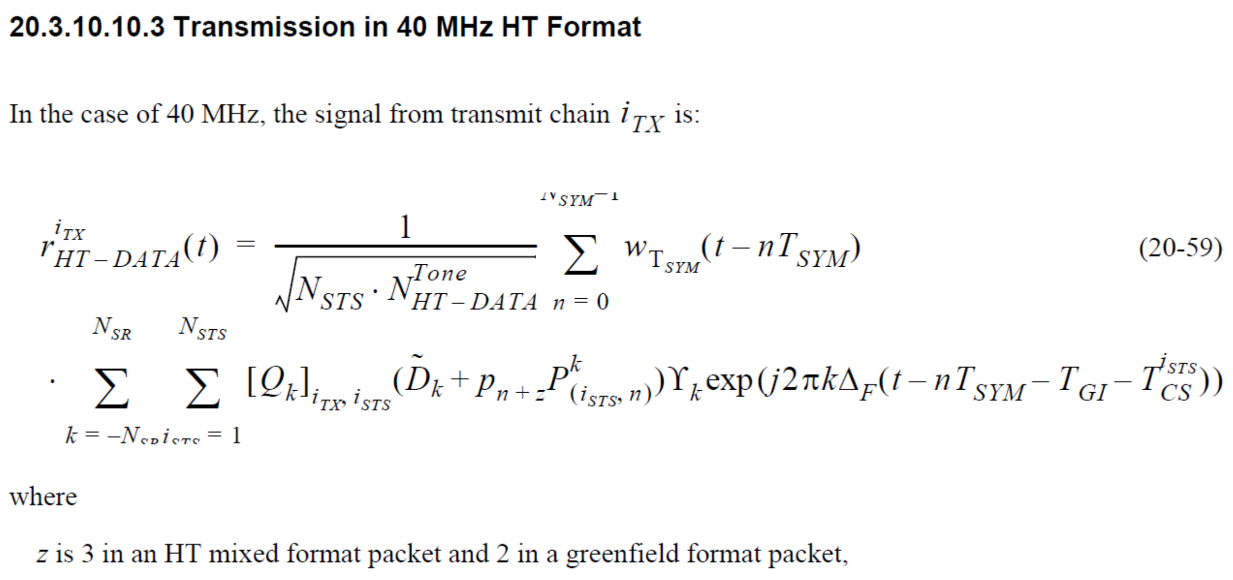
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS}\cdot N_{HT-DATA}^{Tone}}}\sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}}\sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX},i_{STS}}(\tilde{D}_k + p_{n+z}P^k_{(i_{STS},n)})\Upsilon_k \exp(j2\pi k\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{STS}}))$ (20-59) where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

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	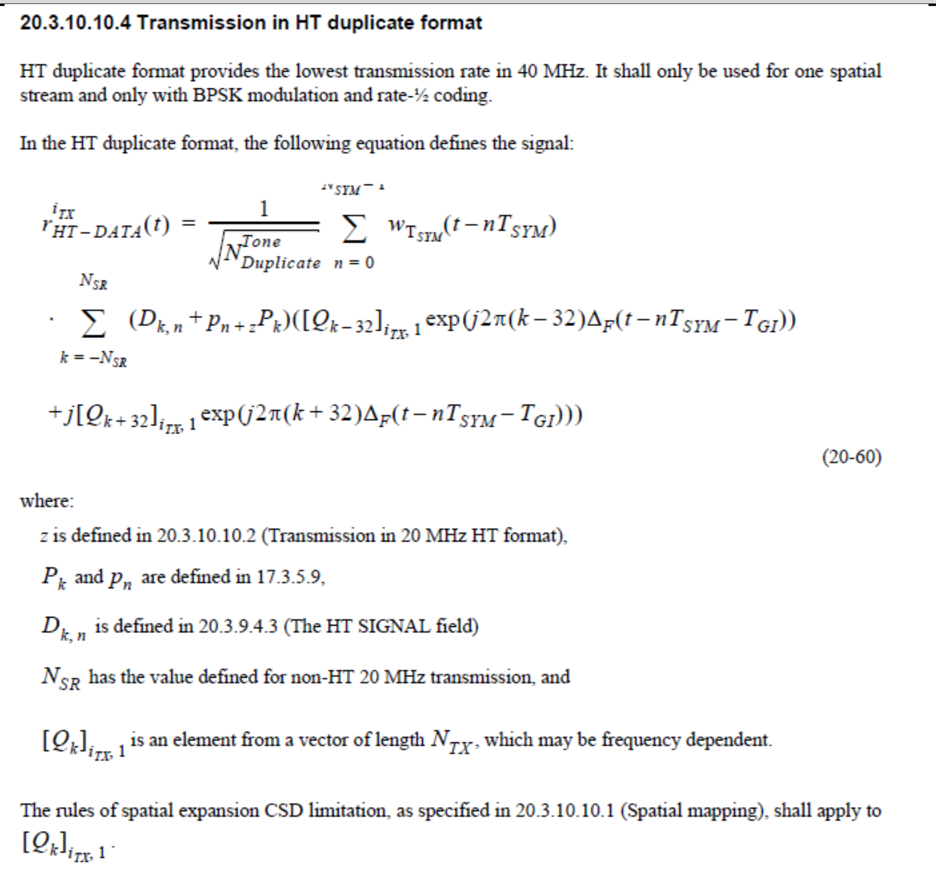 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n}+p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1}\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI})) + j[Q_{k+32}]_{i_{TX},1}\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

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	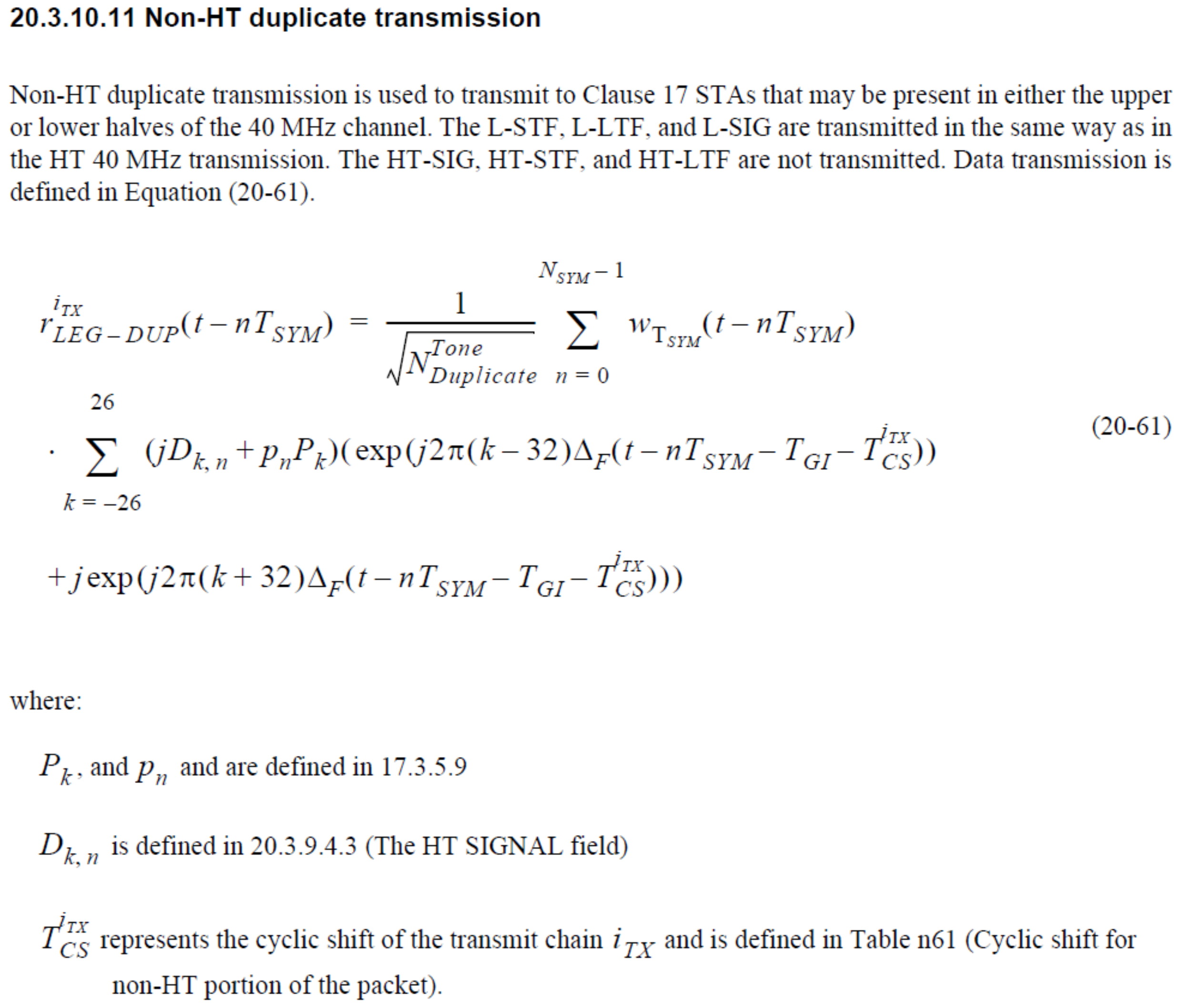 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r^{i_{TX}}_{LEG-DUP}(t-nT_{SYM}) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n}+p_nP_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T^{i_{TX}}_{CS}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

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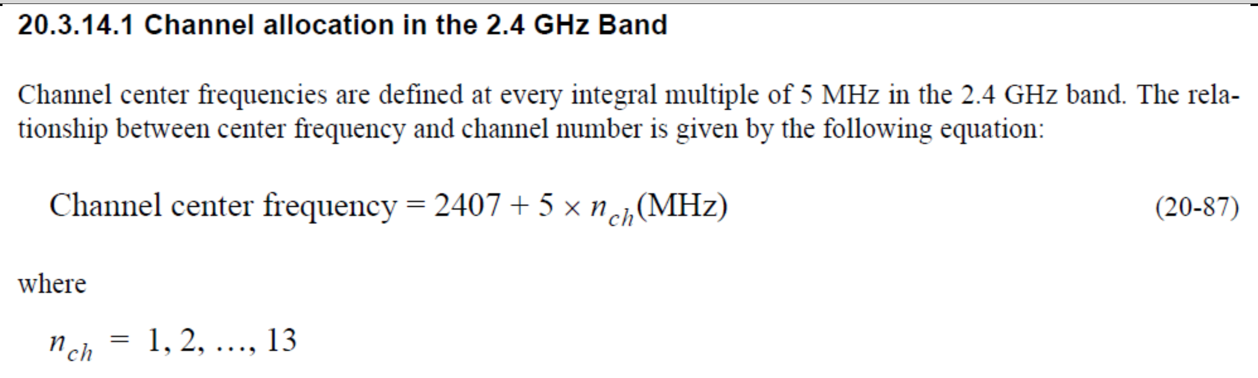
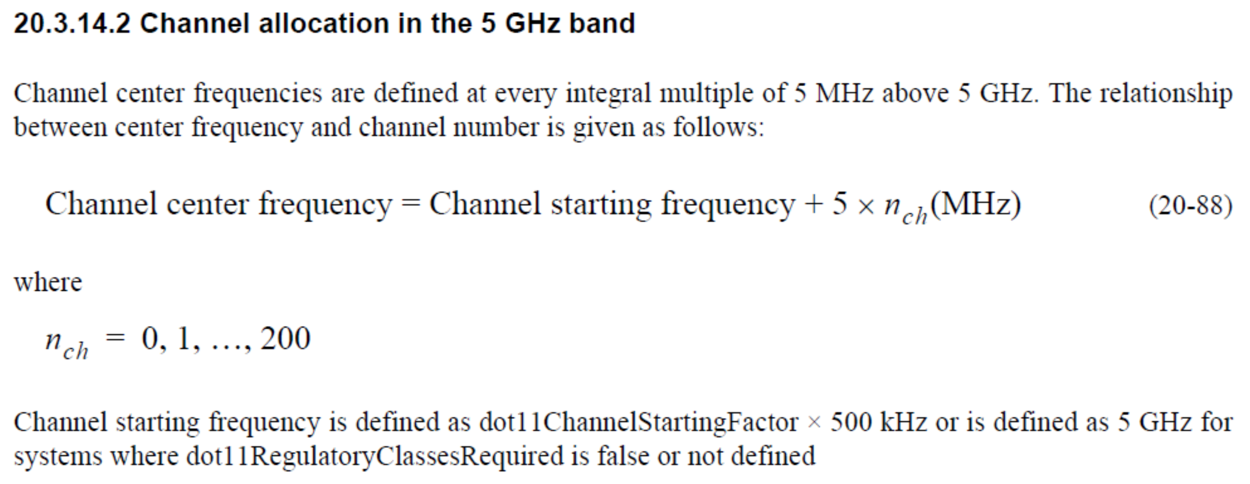
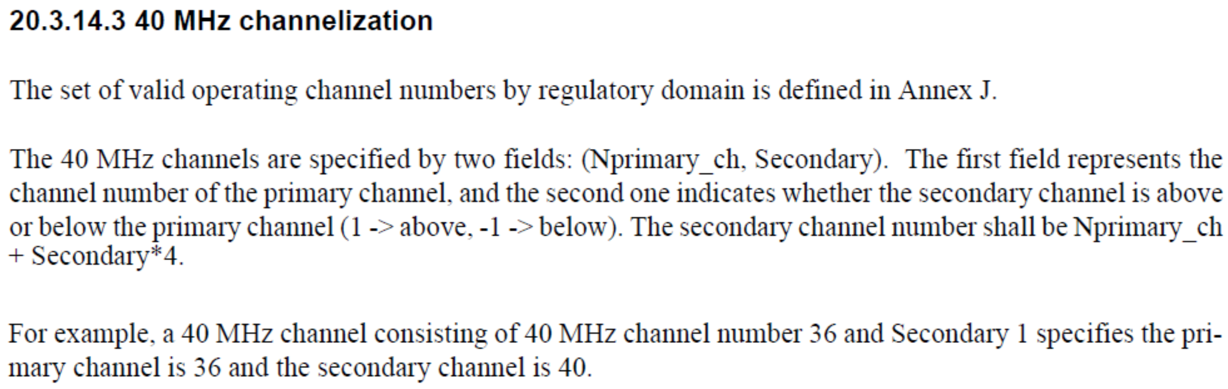
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch} (\text{MHz})$ (20-87) where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch} (\text{MHz})$ (20-88) where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

<table>
<tr><th>Claim 24 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>See, e.g., 802.11n D2.0 § 20.3.20.3

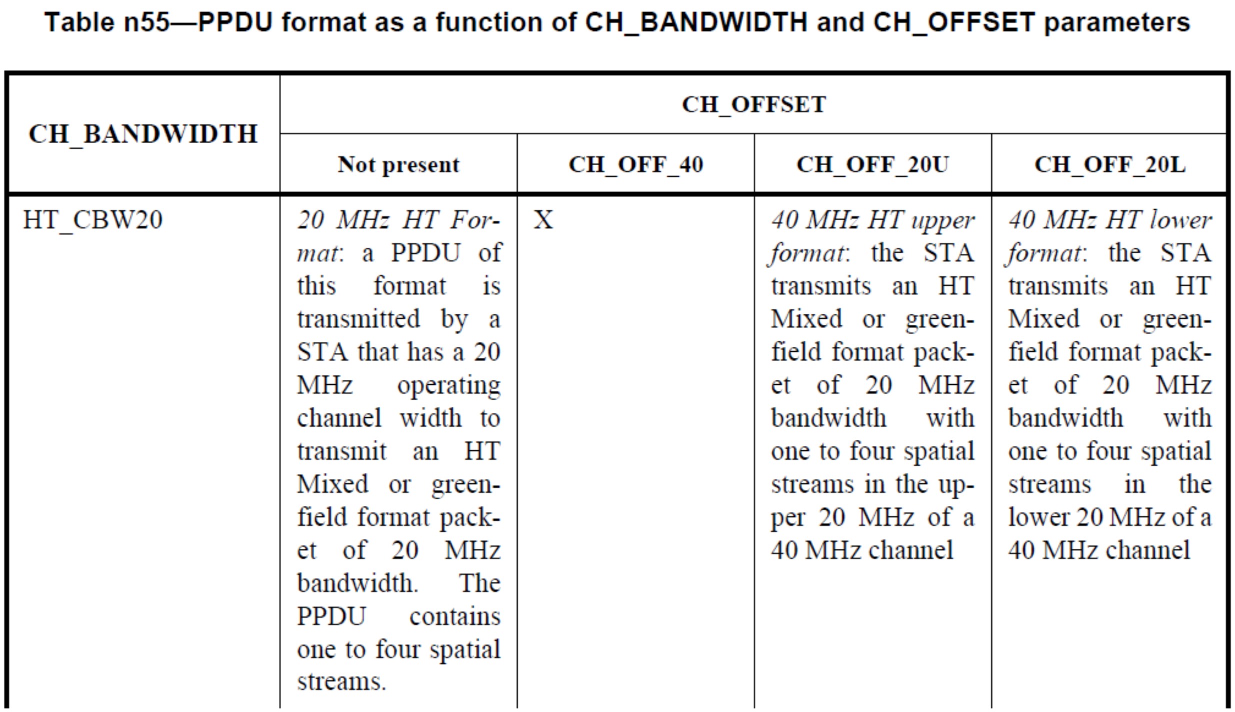
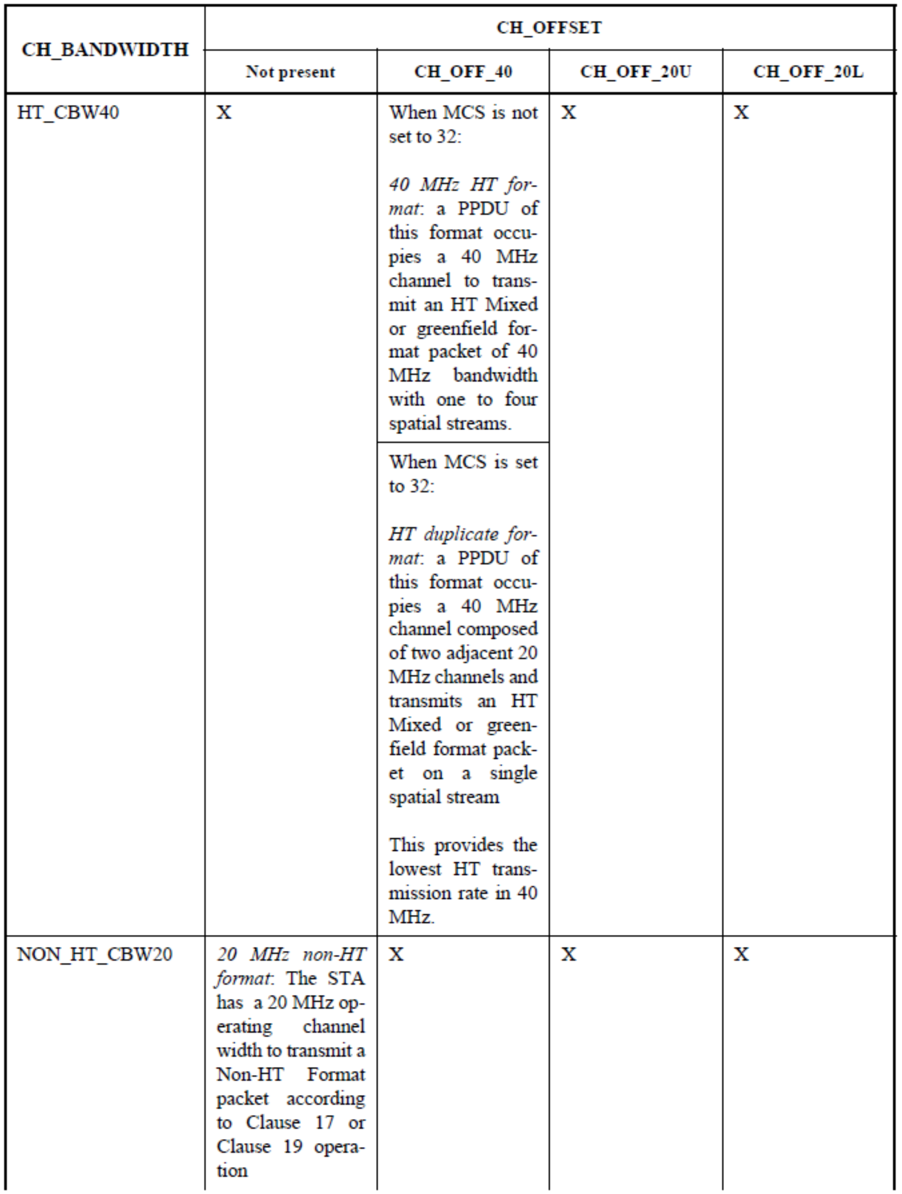
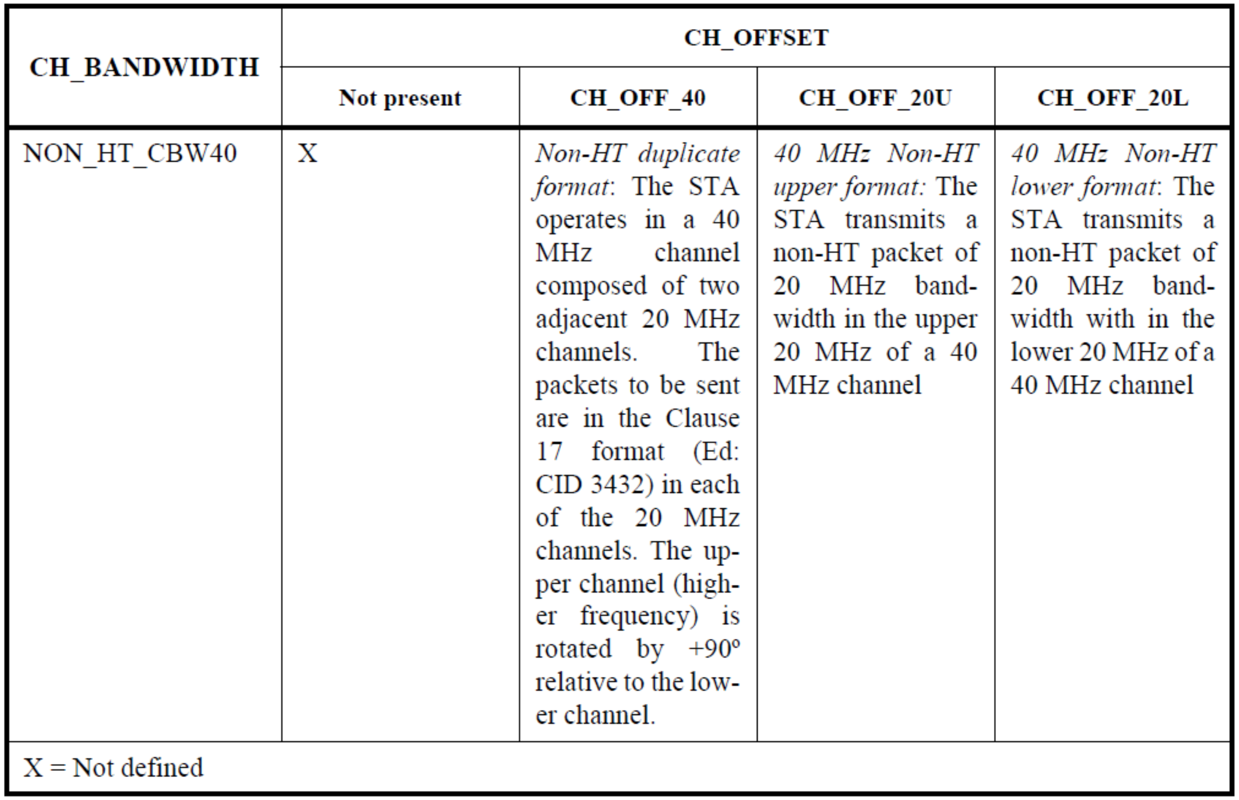
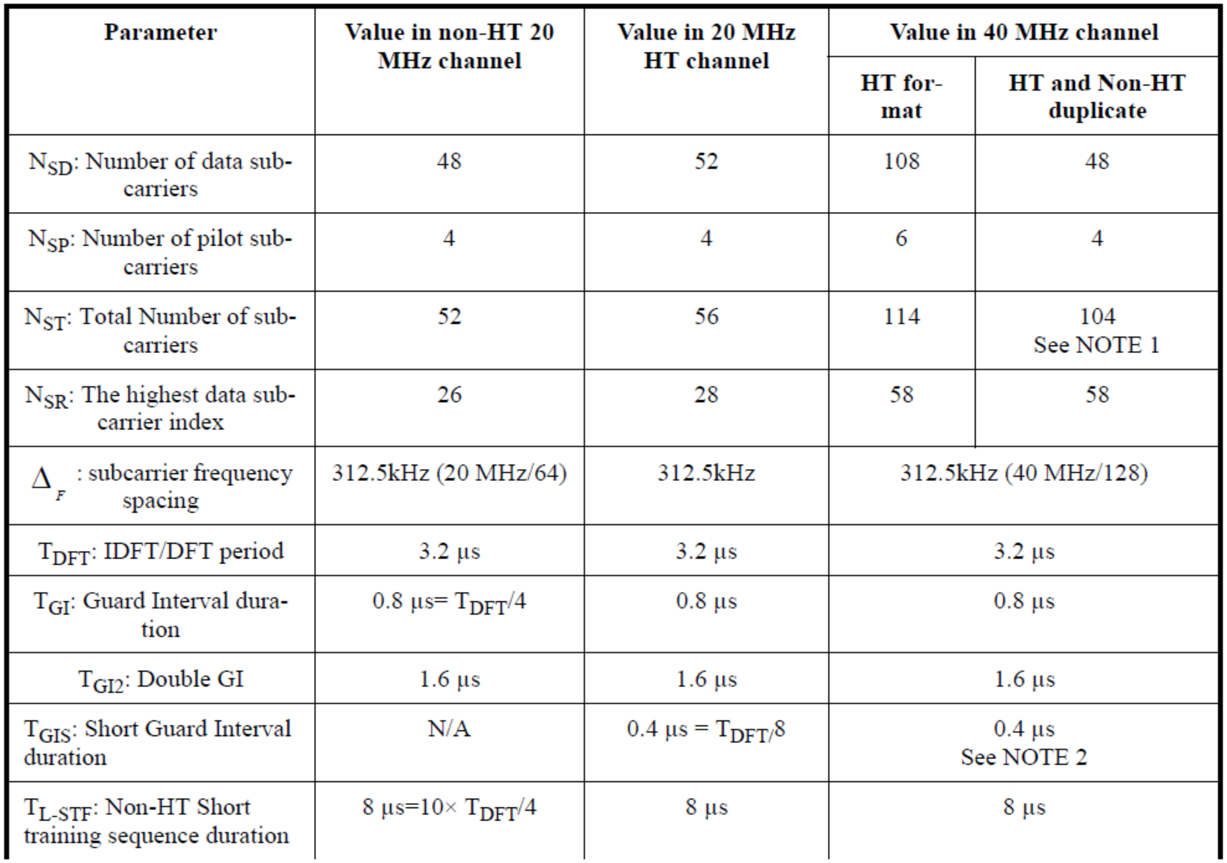



Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters
<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>HT_CBW20</td><td><i>20 MHz HT Format</i>: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.</td><td>X</td><td><i>40 MHz HT upper format</i>: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel</td><td><i>40 MHz HT lower format</i>: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel</td></tr>
</table>
</td></tr>
</table>



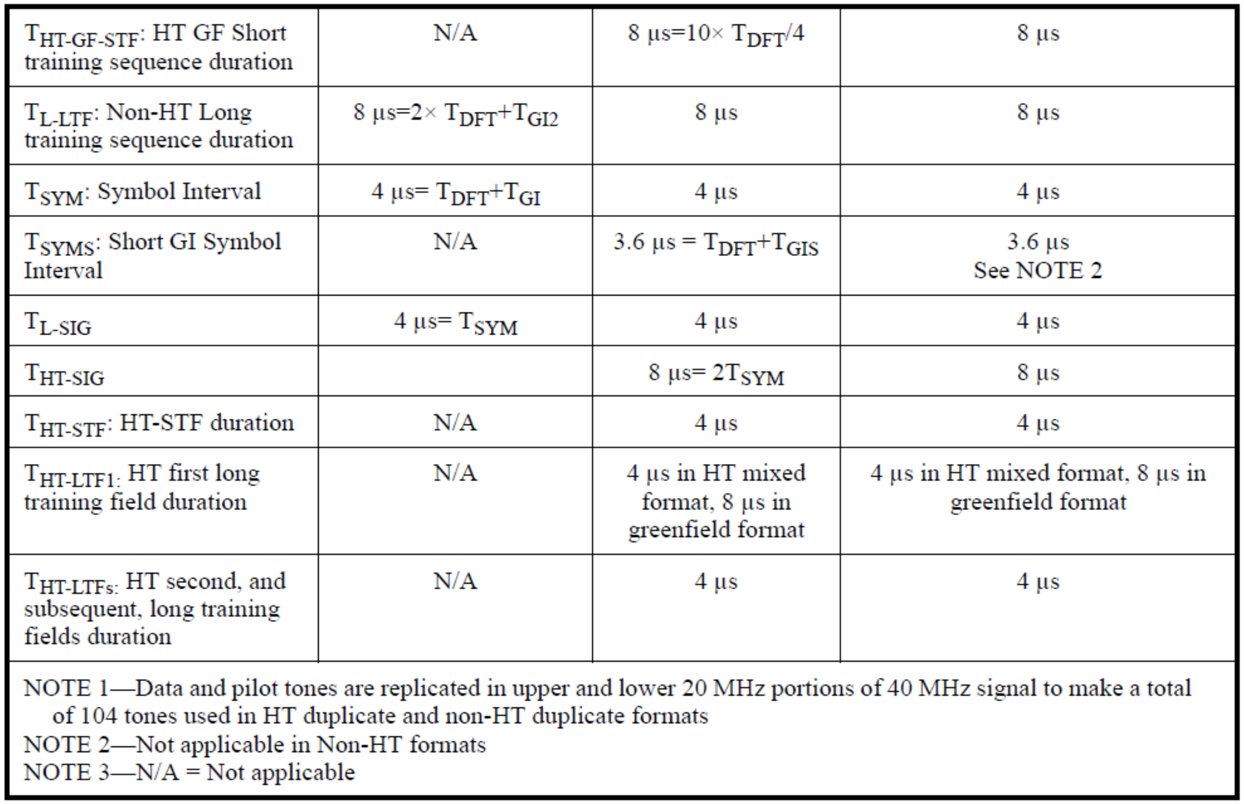
CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

<table>
<tr><th>Claim 24 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>NON_HT_CBW40</td><td>X</td><td><i>Non-HT duplicate format</i>: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90° relative to the lower channel.</td><td><i>40 MHz Non-HT upper format:</i> The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel</td><td><i>40 MHz Non-HT lower format</i>: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel</td></tr>
<tr><td colspan="5">X = Not defined</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n55
</td></tr>
</table>

Claim 24 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	Table n58—Timing related constants 

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0



$T_{\text{HT-GF-STF}}$: HT GF Short training sequence duration	N/A	8 µs=10× $T_{\text{DFT}}/4$	8 µs
$T_{\text{L-LTF}}$: Non-HT Long training sequence duration	8 µs=2× $T_{\text{DFT}}+T_{\text{GI2}}$	8 µs	8 µs
T_{SYM}: Symbol Interval	4 µs= $T_{\text{DFT}}+T_{\text{GI}}$	4 µs	4 µs
T_{SYMS}: Short GI Symbol Interval	N/A	3.6 µs = $T_{\text{DFT}}+T_{\text{GIS}}$	3.6 µs See NOTE 2
$T_{\text{L-SIG}}$	4 µs= T_{SYM}	4 µs	4 µs
$T_{\text{HT-SIG}}$		8 µs= $2T_{\text{SYM}}$	8 µs
$T_{\text{HT-STF}}$: HT-STF duration	N/A	4 µs	4 µs
$T_{\text{HT-LTF1}}$: HT first long training field duration	N/A	4 µs in HT mixed format, 8 µs in greenfield format	4 µs in HT mixed format, 8 µs in greenfield format
$T_{\text{HT-LTFs}}$: HT second, and subsequent, long training fields duration	N/A	4 µs	4 µs

NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable

See, e.g., 802.11n D2.0 Table n58

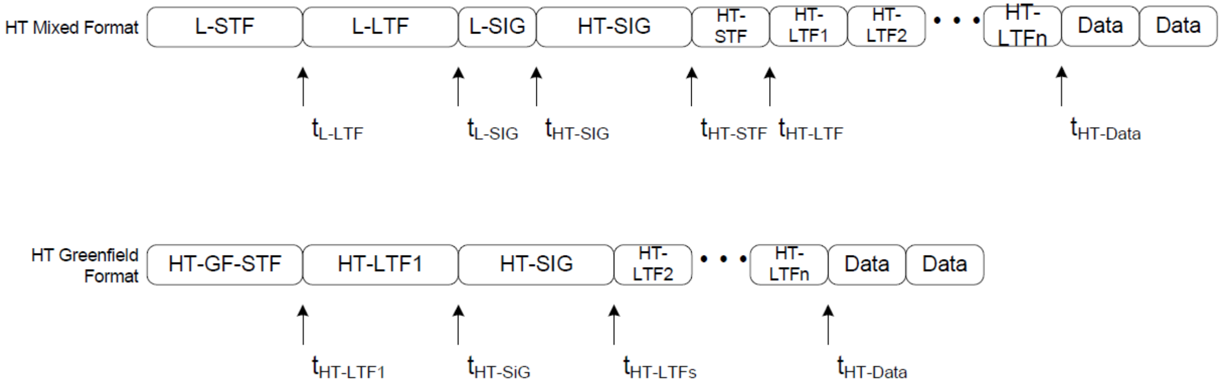
<table>
<tr><th>Claim 24 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>


Figure n65—Timing boundaries for PPDU fields

See, e.g., 802.11n D2.0 Figure n65

Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.
</td></tr>
<tr><td>[24.3] a second down-converter circuit having a first input coupled to receive the first up-converted signal, a second input coupled to receive a second demodulation signal having a second RF frequency different</td><td>802.11n D2.0 discloses “a second down-converter circuit having a first input coupled to receive the first up-converted signal, a second input coupled to receive a second demodulation signal having a second RF frequency different than the first RF frequency, and an output, wherein the second down-converter outputs a second down-converted signal on the second down-converter output, wherein the first up-converted signal comprises a first signal modulated at the first RF frequency and a second signal modulated at the second RF frequency.” See, e.g.:</td></tr>
</table>

Claim 24 of the '802 Patent	Prior Art Reference – 802.11n D2.0
than the first RF frequency, and an output, wherein the second down-converter outputs a second down-converted signal on the second down-converter output, wherein the first up-converted signal comprises a first signal modulated at the first RF frequency and a second signal modulated at the second RF frequency; and	**high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19 **non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0

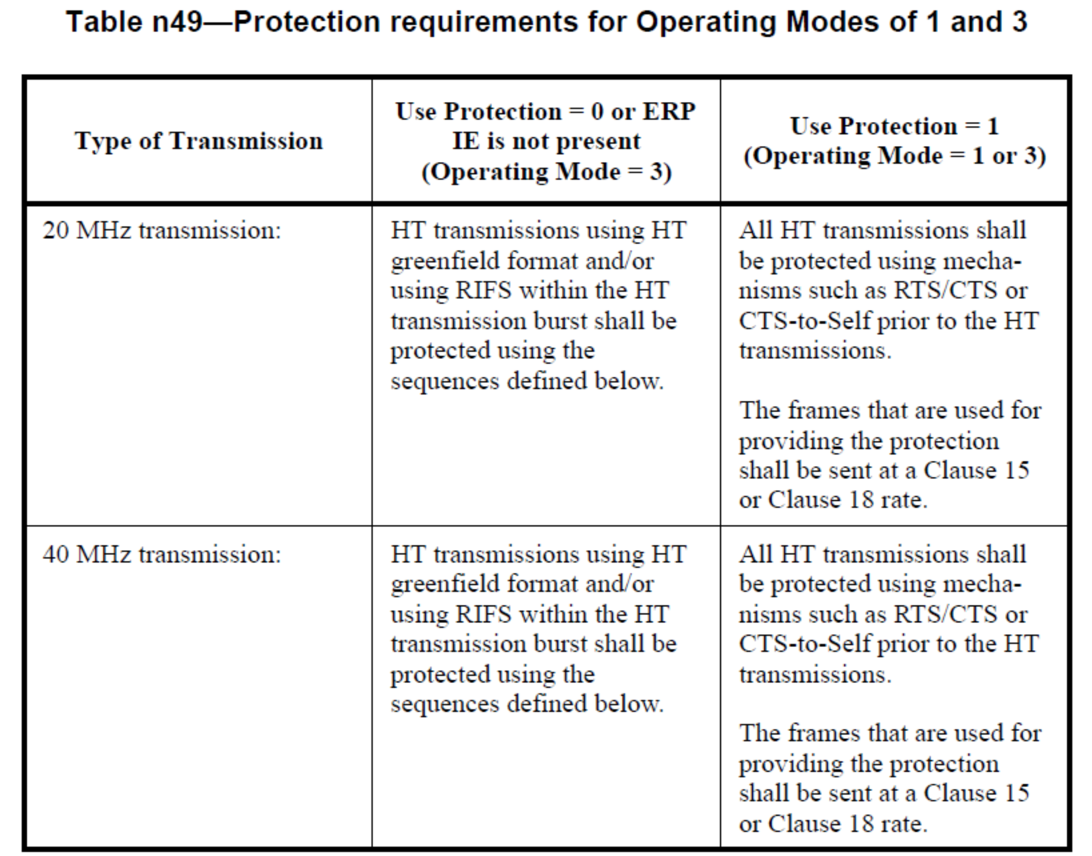
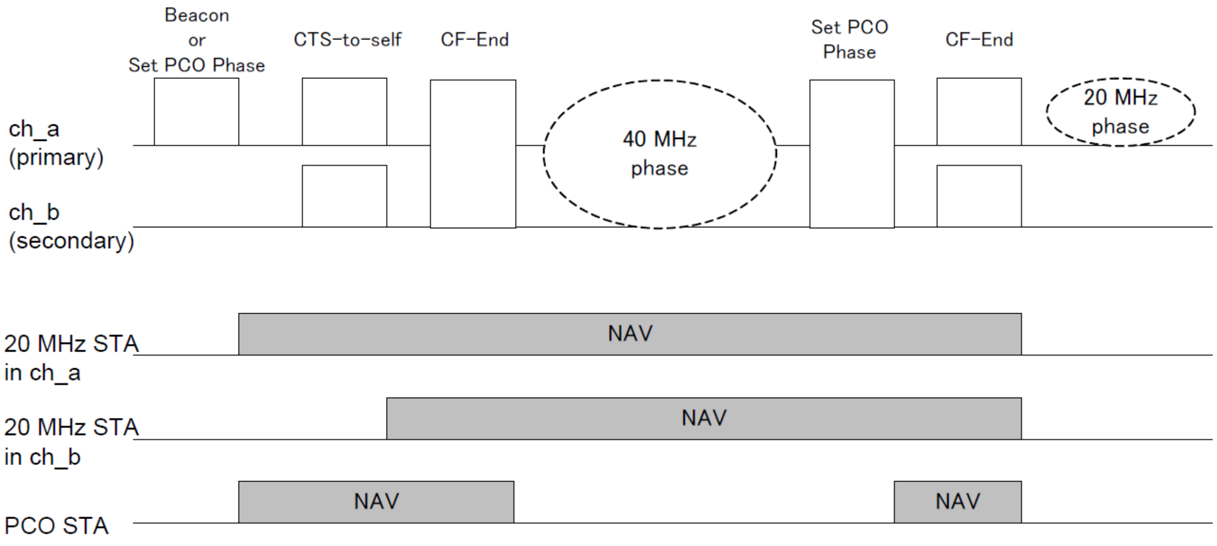


Table n49—Protection requirements for Operating Modes of 1 and 3

Type of Transmission	Use Protection = 0 or ERP IE is not present (Operating Mode = 3)	Use Protection = 1 (Operating Mode = 1 or 3)
20 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.
40 MHz transmission:	HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.	All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions. The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.
NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).

Claim 24 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 24 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

Claim 24 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

Claim 24 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t\right)\right\}$ (20-1) where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

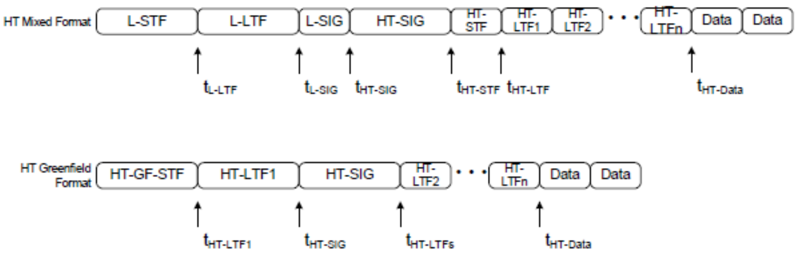


Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field}, determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) \; = \; & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right) T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}\left(t - t_{HT-DATA}\right) \end{aligned} \qquad (20\text{-}2)$$

where

$$t_{L-LTF} = T_{L-STF}$$

$$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$$

$$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$$

$$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{HT-GF-STF}^{(i_{TX})}(t) + r_{HT-LTF1}^{(i_{TX})}(t - t_{HT-LTF1}) \\ & + r_{HT-SIG}^{(i_{TX})}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX}, i_{LTF})}(t - t_{HT-LTFs} - (i_{LTF} - 2)T_{HT-LTFs}) \\ & + r_{HT-DATA}^{(i_{TX})}(t - t_{HT-DATA}) \end{aligned} \qquad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r_{\text{Field}}^{(i_{TX})}(t)$, is defined via the discrete Fourier transform as

$$r_{\text{Field}}^{(i_{TX})}(t) = \frac{1}{\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X_k^{(i_{TX})} \exp(j2\pi k \Delta_F t) \qquad (20\text{-}4)$$

This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X_k^{(i_{TX})}$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1, k \le 0, \text{ in a 40 MHz channel} \\ j, k > 0, \text{ in a 40 MHz channel} \end{cases} \qquad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \qquad (20\text{-}6)$$

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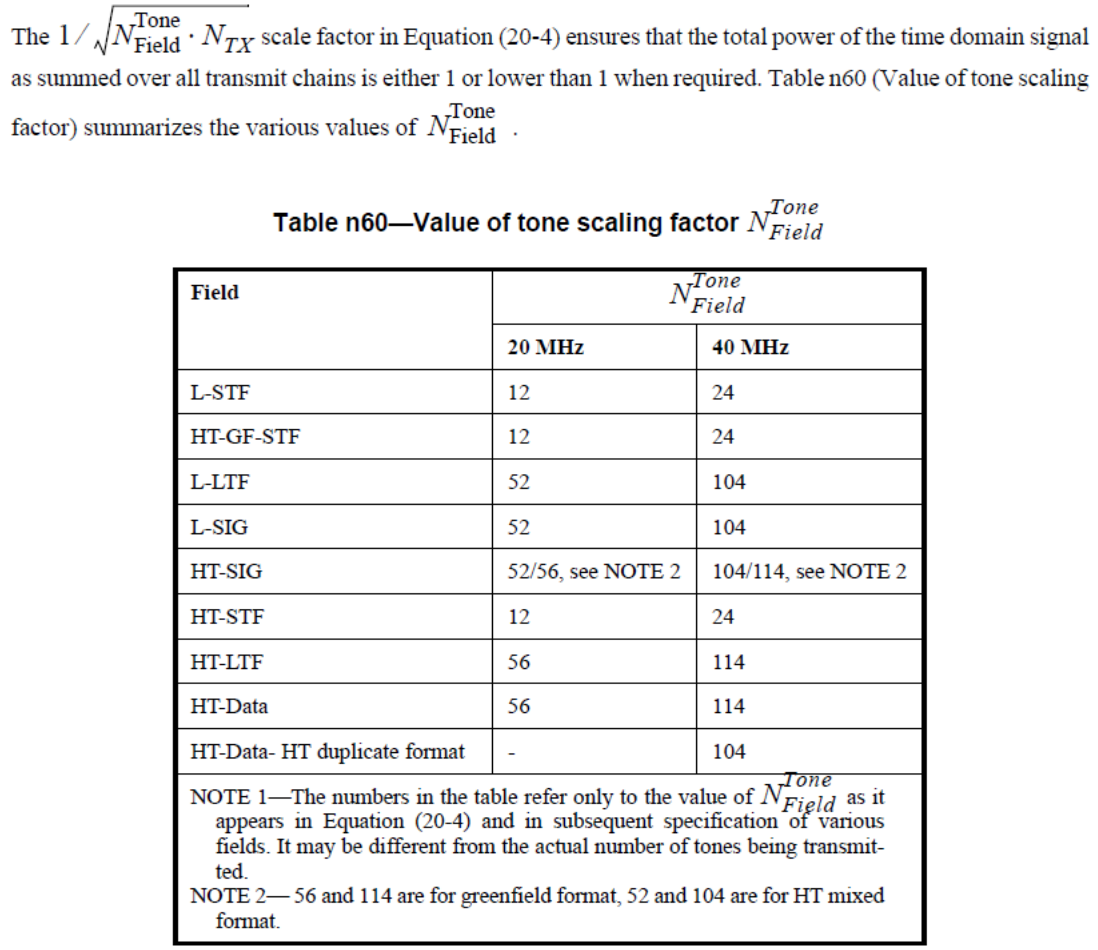


The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	**40 MHz**
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

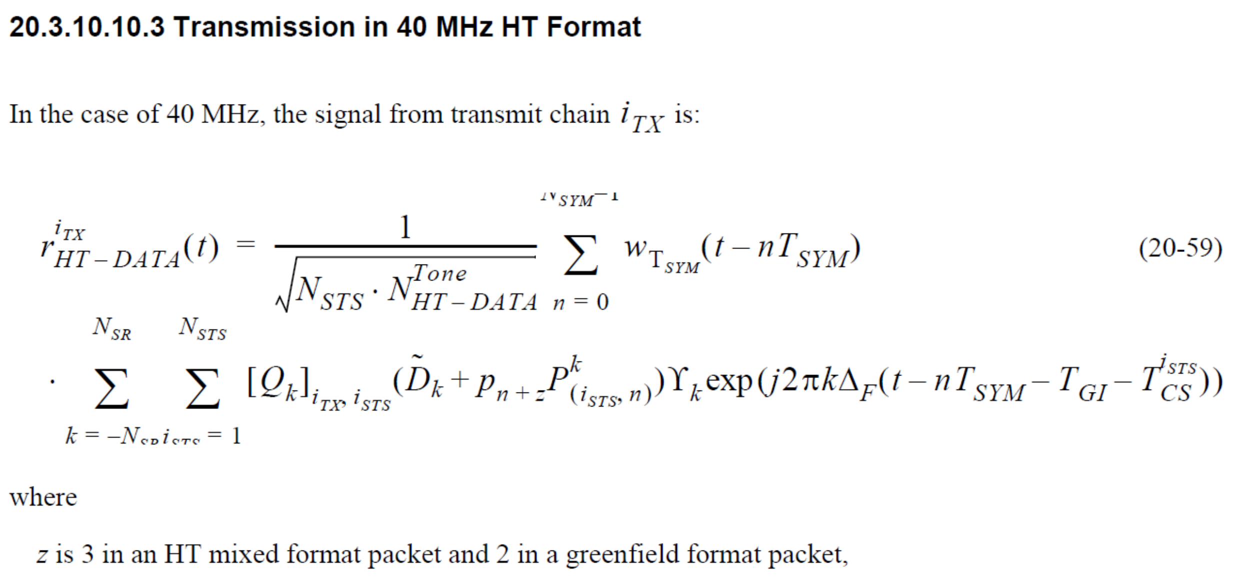
NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

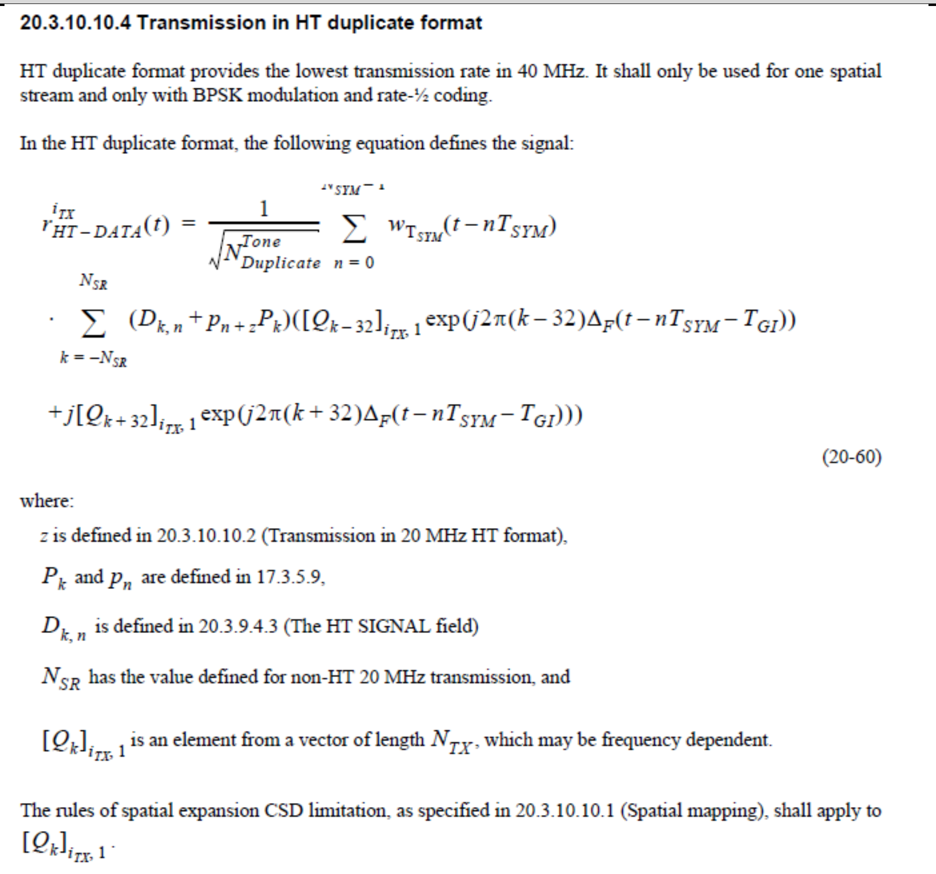
See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

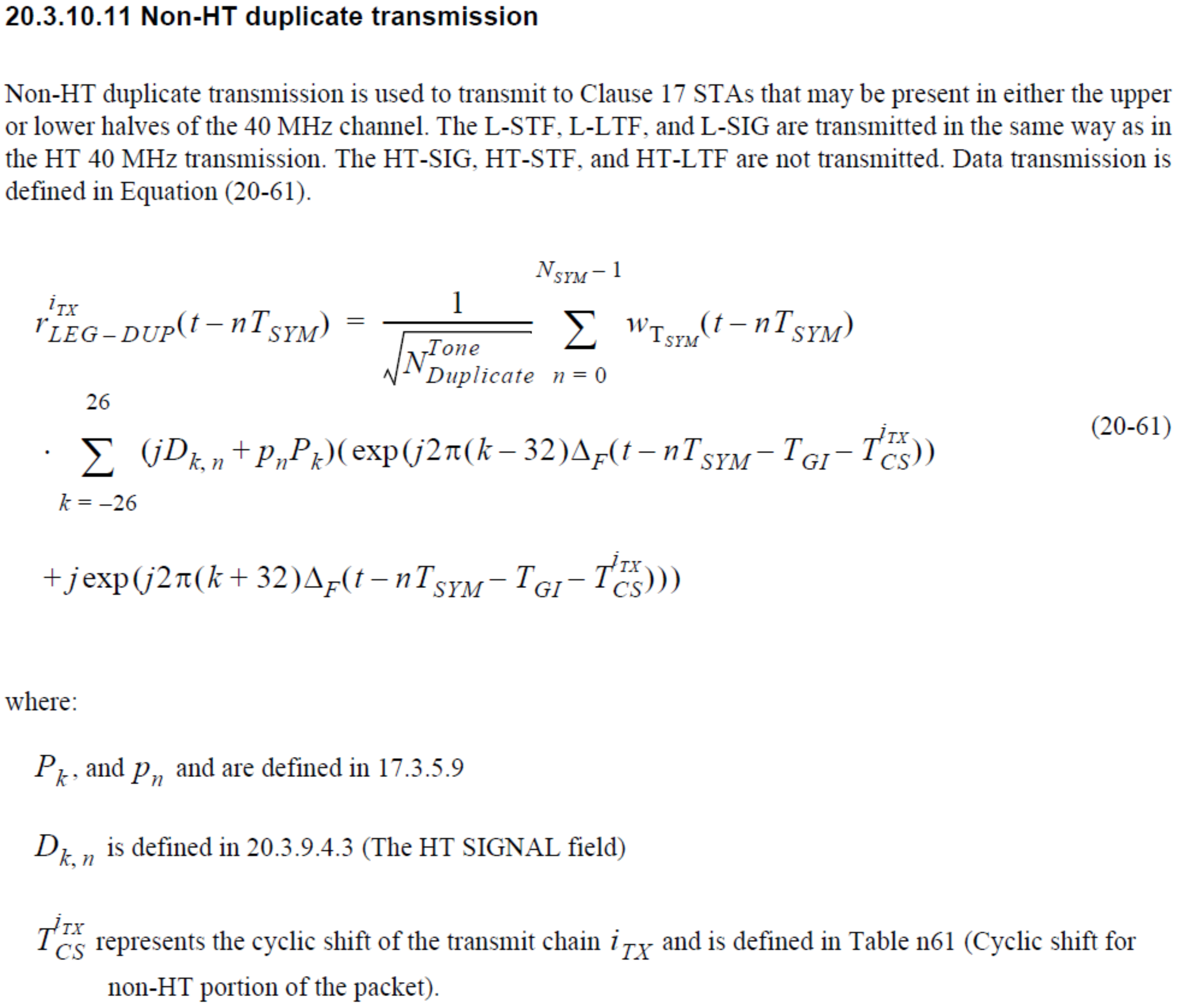
20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

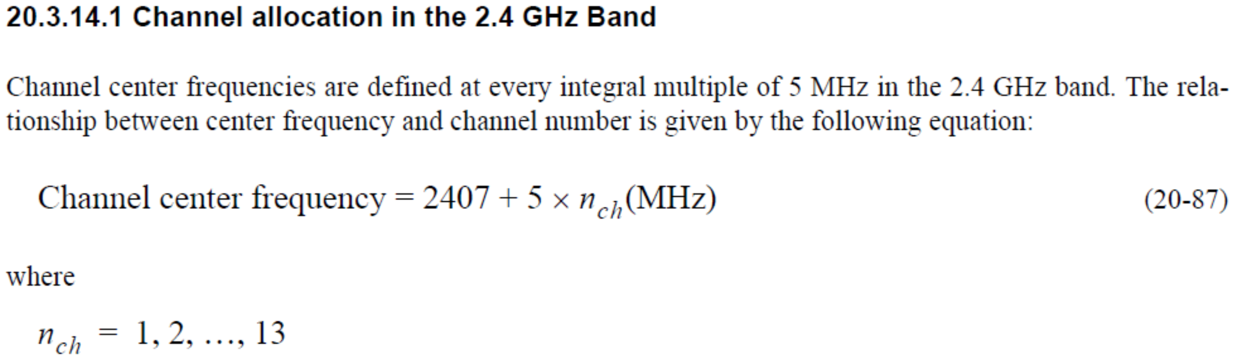
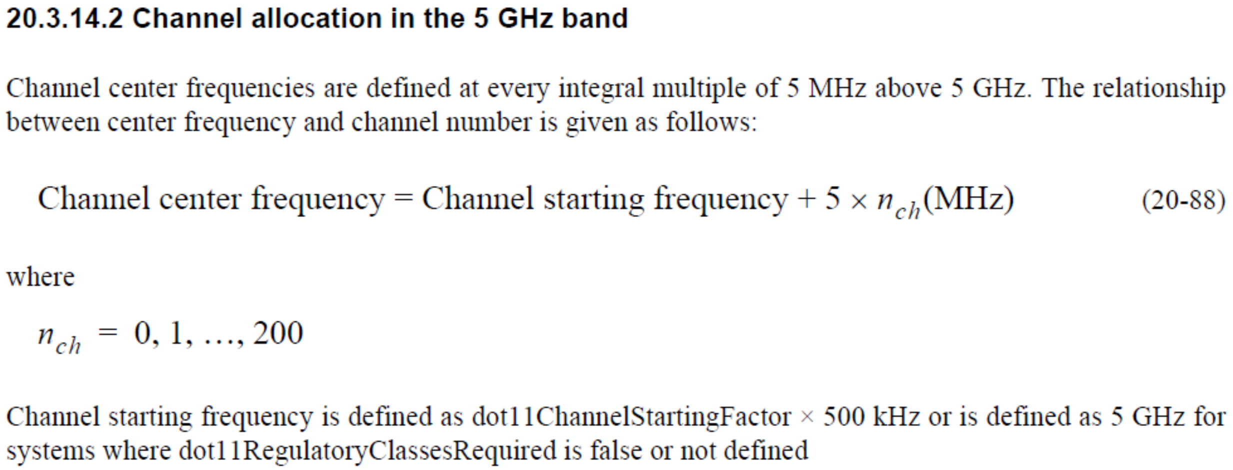
When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

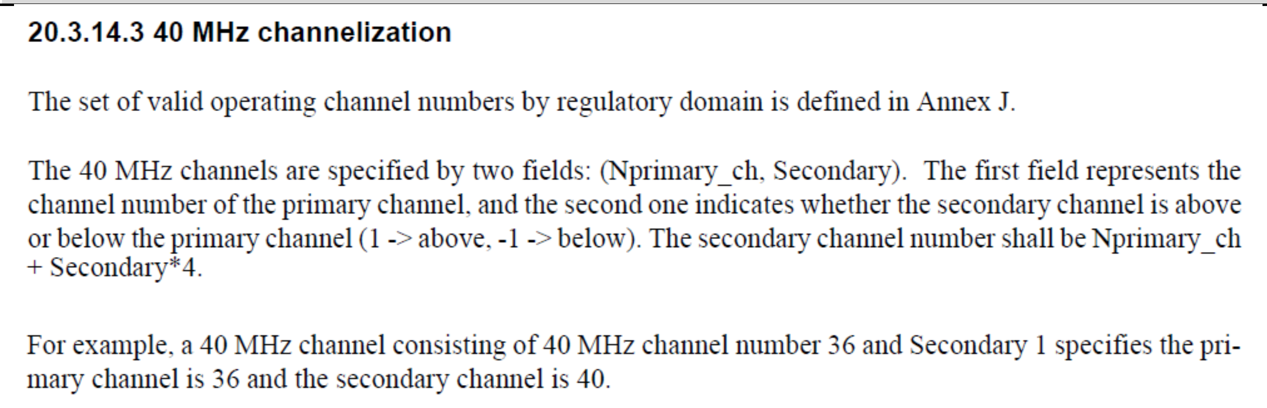
Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS} \cdot N^{Tone}_{HT-DATA}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM})$ (20-58) $\cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P^k_{(i_{STS},n)}) \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T^{i_{STS}}_{CS}))$ where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

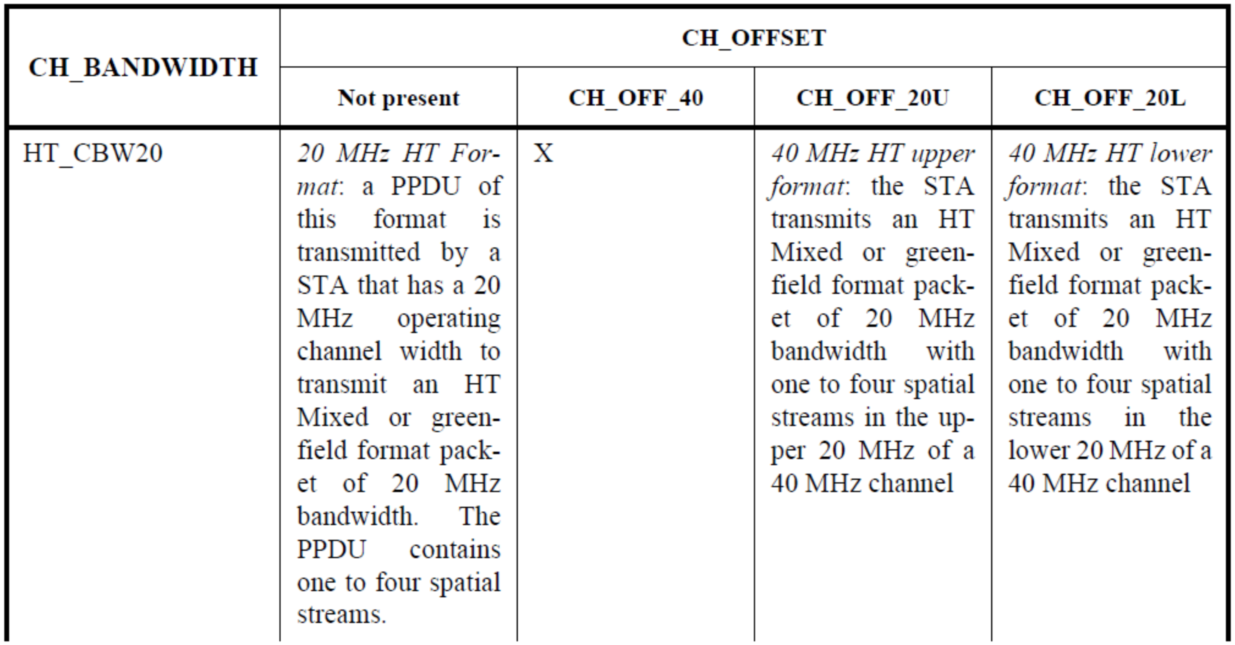
Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $$r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_k + p_{n+z} P_{(i_{STS}, n)}^{k}) \Upsilon_k \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}})) \quad (20\text{-}59)$$ where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.10.4 Transmission in HT duplicate format** HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding. In the HT duplicate format, the following equation defines the signal: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM})$ $\cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n}+p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}))$ $+j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI})))$ (20-60) where: z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format), P_k and p_n are defined in 17.3.5.9, $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) N_{SR} has the value defined for non-HT 20 MHz transmission, and $[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent. The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$. See, e.g., 802.11n D2.0 § 20.3.10.10.4

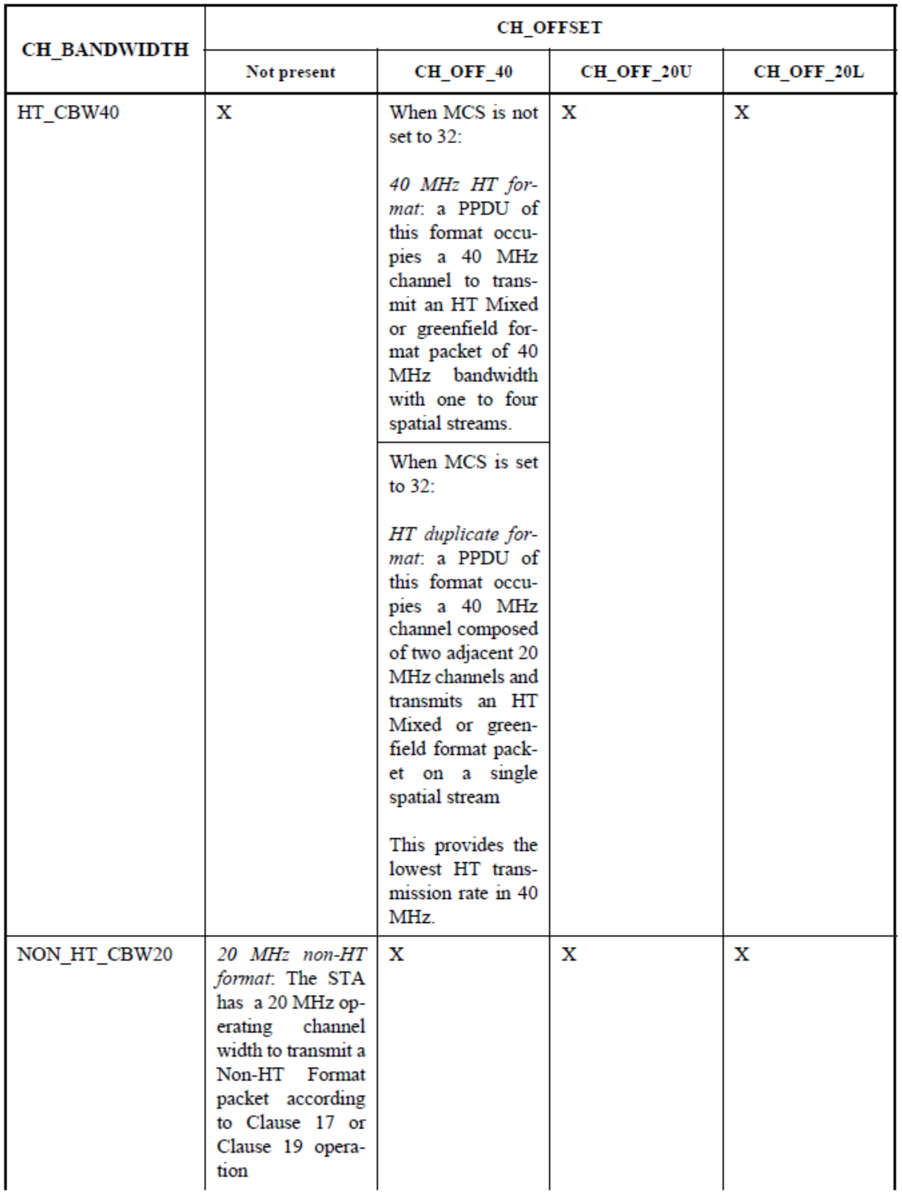
Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r^{i_{TX}}_{LEG-DUP}(t-nT_{SYM}) = \frac{1}{\sqrt{N^{Tone}_{Duplicate}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n}+p_nP_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T^{i_{TX}}_{CS})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T^{i_{TX}}_{CS}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz})$ (20-87) where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz})$ (20-88) where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

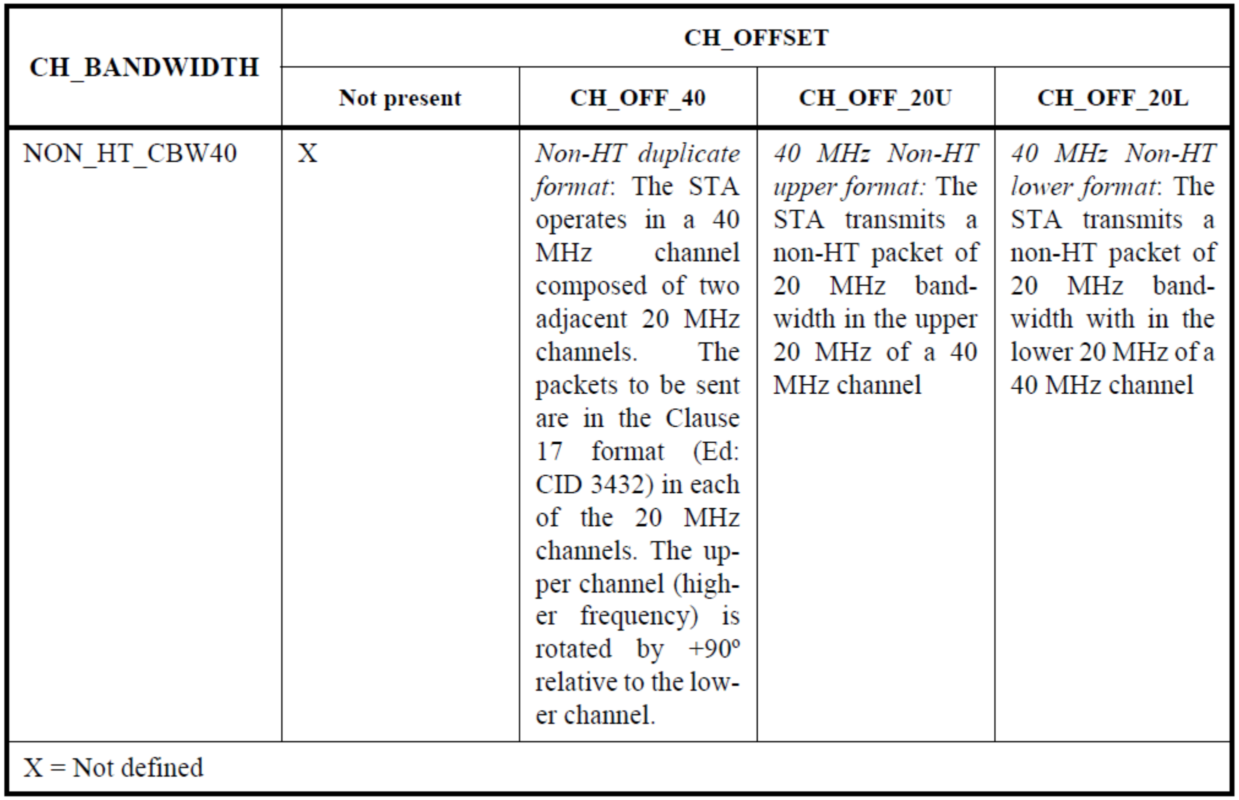
Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3 **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2 **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

Claim 24 of the ’802 Patent	**Prior Art Reference – 802.11n D2.0**
	See, e.g., 802.11n D2.0 § 20.3.20.3 **Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters** 

CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel



CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

<table>
<tr><th>Claim 24 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>NON_HT_CBW40</td><td>X</td><td>*Non-HT duplicate format*: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.</td><td>*40 MHz Non-HT upper format:* The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel</td><td>*40 MHz Non-HT lower format*: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel</td></tr>
<tr><td colspan="5">X = Not defined</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n55
</td></tr>
</table>

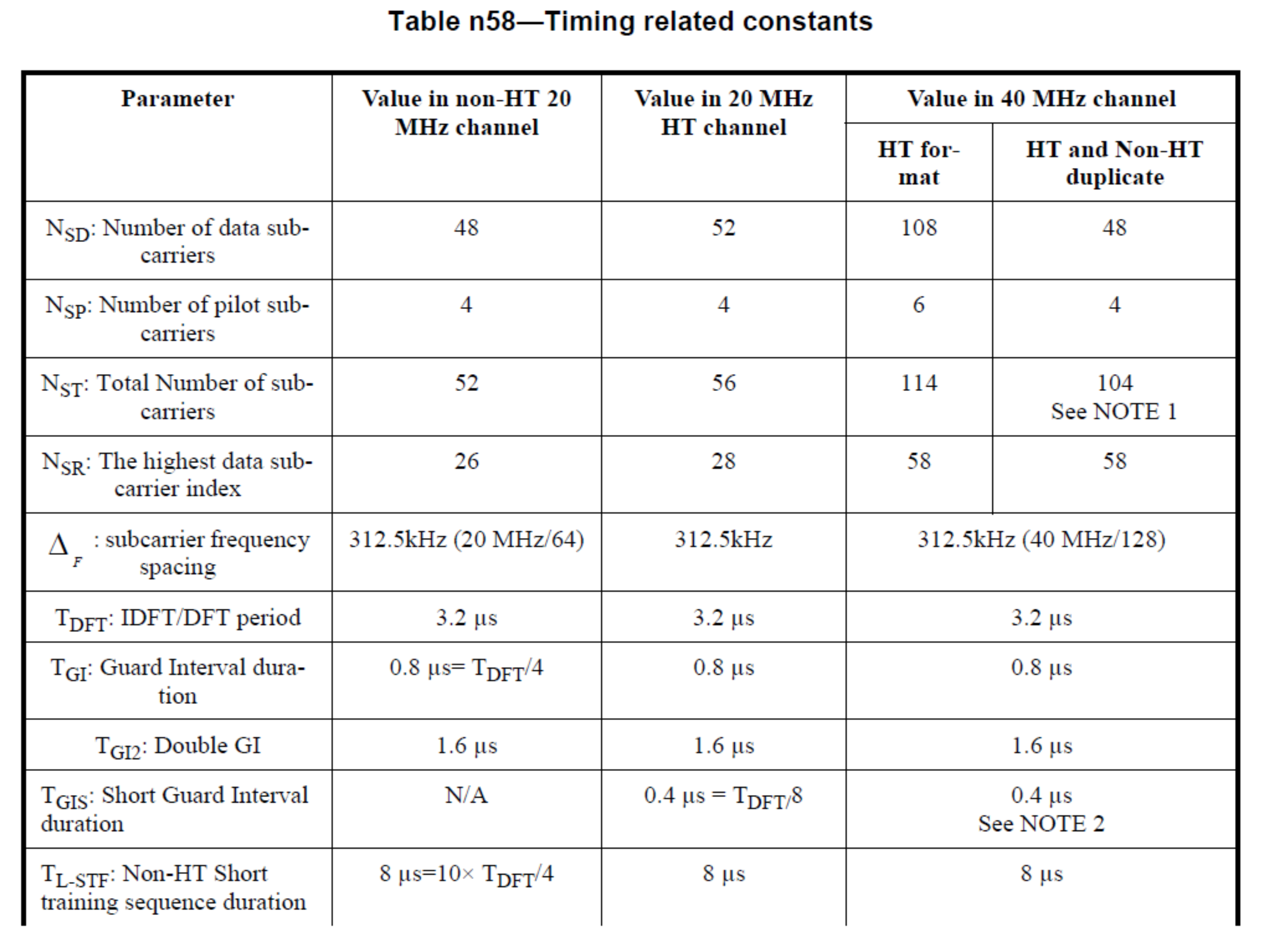
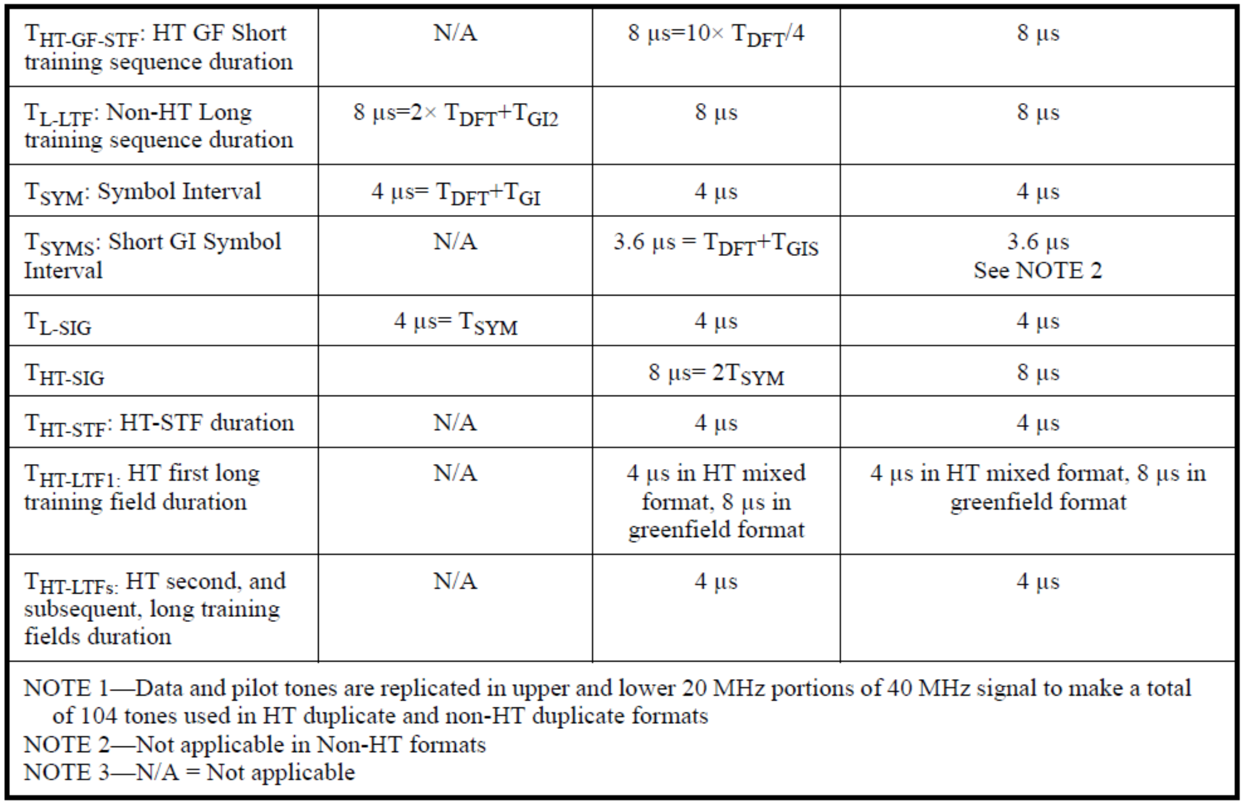
Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	

Table n58—Timing related constants

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F: subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

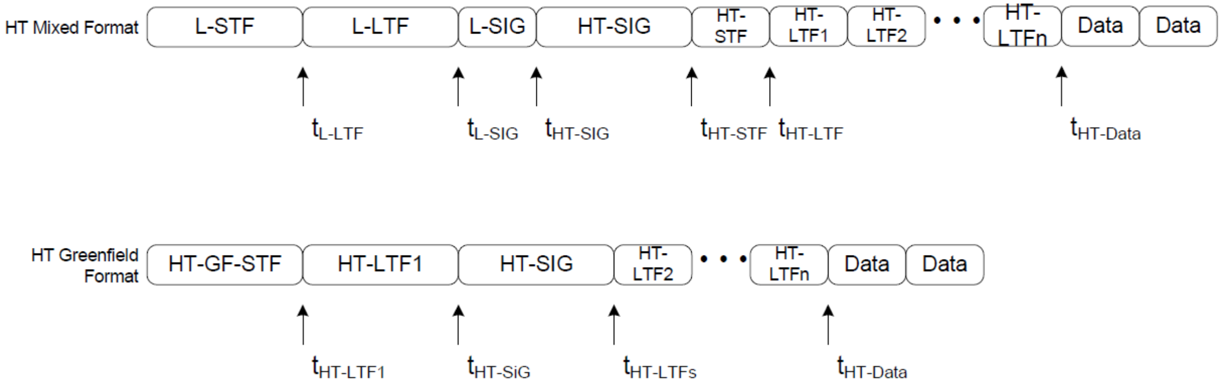
Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0



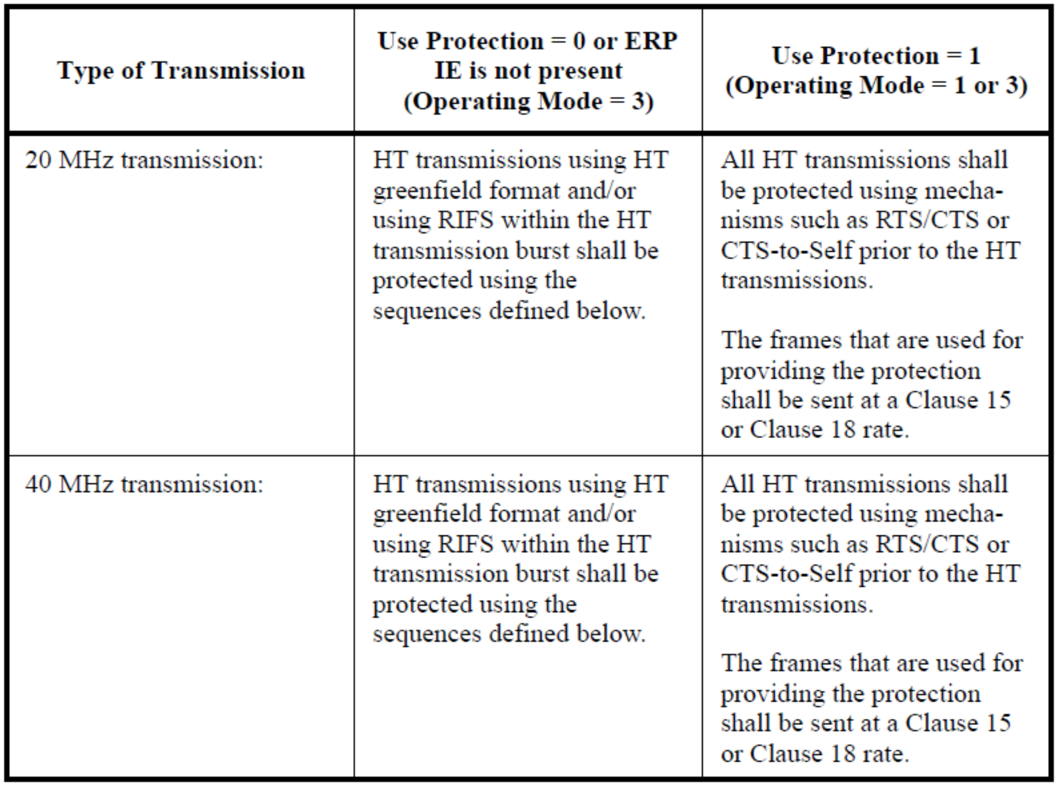
$T_{HT\text{-}GF\text{-}STF}$: HT GF Short training sequence duration	N/A	8 µs=10× $T_{DFT}/4$	8 µs
$T_{L\text{-}LTF}$: Non-HT Long training sequence duration	8 µs=2× $T_{DFT}+T_{GI2}$	8 µs	8 µs
T_{SYM}: Symbol Interval	4 µs= $T_{DFT}+T_{GI}$	4 µs	4 µs
T_{SYMS}: Short GI Symbol Interval	N/A	3.6 µs = $T_{DFT}+T_{GIS}$	3.6 µs See NOTE 2
$T_{L\text{-}SIG}$	4 µs= T_{SYM}	4 µs	4 µs
$T_{HT\text{-}SIG}$		8 µs= $2T_{SYM}$	8 µs
$T_{HT\text{-}STF}$: HT-STF duration	N/A	4 µs	4 µs
$T_{HT\text{-}LTF1}$: HT first long training field duration	N/A	4 µs in HT mixed format, 8 µs in greenfield format	4 µs in HT mixed format, 8 µs in greenfield format
$T_{HT\text{-}LTFs}$: HT second, and subsequent, long training fields duration	N/A	4 µs	4 µs

NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable

See, e.g., 802.11n D2.0 Table n58

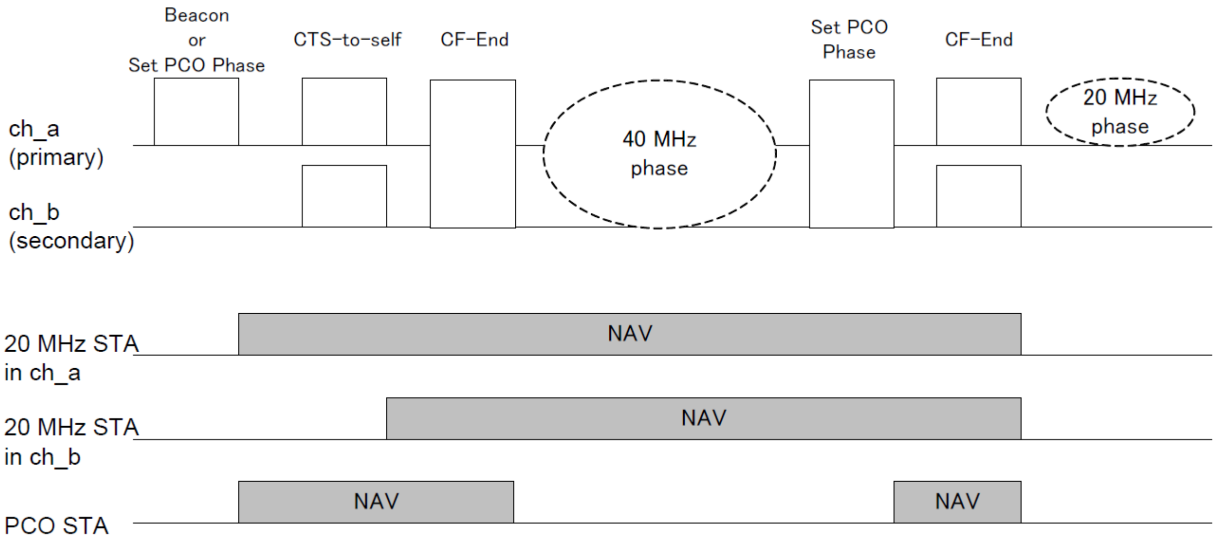
Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.
[24.4] a filter having an input coupled to the output of the first down-converter and the output of the second down-converter, and in accordance therewith, the filter receives	802.11n D2.0 discloses “a filter having an input coupled to the output of the first down-converter and the output of the second down-converter, and in accordance therewith, the filter receives the first and second down-converted signals.” See, e.g.: **high throughput duplicate format (HT duplicate format)**: A PPDU format of the HT PHY in which signals in two halves of the occupied channel width contain the same information. This is the HT mode that supports the lowest rate. See, e.g., 802.11n D2.0 § 3.n19

Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
the first and second down-converted signals.	**non-HT duplicate:** A mode of operation of the PHY that duplicates a 20 MHz non-HT transmission in two adjacent 20 MHz channels, allowing a non-HT BSS on either channel to receive the transmission. See, e.g., 802.11n D2.0 § 3.n32 **9.13.3.1 General** HT transmissions shall be protected if there are other STAs (HT or non-HT) that cannot interpret HT transmissions correctly. The fields Operating Mode and Non-greenfield STAs Present in the HT Information element within the Beacon and Probe Response frames are used to determine if protection is required for transmission. When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required since all associated HT stations in the BSS are capable of decoding HT mixed format and HT greenfield format transmissions. When the Operating Mode field is set to 0 or 2 and the Non-greenfield STAs Present field is set to 1, HT transmissions that use the greenfield preamble shall be protected. NOTE 1—When the Operating Mode field is set to 0 or 2 and Non-greenfield STAs Present field is set to 0, no protection is required for 40 MHz transmissions since enough of the preamble is sent on both 20 MHz halves of the 40 MHz transmission to ensure that a 20 MHz STA is able to decode the preamble and infer the duration of the transmission. NOTE 2—When the BSS is operating in the 2.4 GHz band and when the Operating Mode field is set to 0 or 2, there are no non-HT STAs in the BSA and thus the Use Protection subfield of the ERP Information Element is set to 0. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 0, HT transmissions may be protected accoding to implementation dependent criteria. When the Operating Mode field is set to 1, the Use Protection field in the ERP Information Element is set to 0 and the Non-greenfield STAs Present field is set to 1, HT transmissions using HT greenfield format shall be protected. When the Operating Mode field is set to 1 and the Use Protection field in the ERP Information Element is set to 1, HT transmissions shall be protected using the mechanisms described in Table n49 (Protection requirements for Operating Modes of 1 and 3) When the Operating Mode field is set to 3, HT transmissions shall be protected. The type of protection that is required depends on the type of transmission as well as the type of the non-HT STAs that are present in the BSS. The specific mechanisms that are to be used for protection for Operating Mode set to 3 are described in Table n49 (Protection requirements for Operating Modes of 1 and 3)

<table>
<tr><th>Claim 24 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>
Table n49—Protection requirements for Operating Modes of 1 and 3

<table>
<tr><th>Type of Transmission</th><th>Use Protection = 0 or ERP IE is not present (Operating Mode = 3)</th><th>Use Protection = 1 (Operating Mode = 1 or 3)</th></tr>
<tr><td>20 MHz transmission:</td><td>HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.</td><td>All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions.
The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.</td></tr>
<tr><td>40 MHz transmission:</td><td>HT transmissions using HT greenfield format and/or using RIFS within the HT transmission burst shall be protected using the sequences defined below.</td><td>All HT transmissions shall be protected using mechanisms such as RTS/CTS or CTS-to-Self prior to the HT transmissions.
The frames that are used for providing the protection shall be sent at a Clause 15 or Clause 18 rate.</td></tr>
</table>

If the transmission requires protection and Use Protection field within the ERP Information Element is set to 0 or the ERP Information Element is not present in the Beacon, HT transmissions shall be protected in one of the following ways:
a) Control frames such as RTS/CTS or CTS-to-self prior to the HT transmissions:
1) For 20 MHz transmissions, use the rates defined in Clause 17 or Clause 19
2) For 40 MHz transmissions, use the non-HT duplicate frames defined in Clause 20.
NOTE—The rate for protection frames are selected based on the rules described in 9.6.3.1 (Rate selection for control frames that initialize a TXOP) and 9.6.3.2 (Rate selection for control frames that are not control response frames).
</td></tr>
</table>

Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	b) Using a non-HT preamble, transmit first a PPDU that requires a response frame. The remaining TXOP following the first PPDU exchange may contain GF and/or RIFS sequences. c) L-SIG TXOP protection d) Using a mixed format preamble, transmit first a PPDU that requires a response that is sent as a non-HT frame or non-HT duplicate frame. The remaining TXOP following the first PPDU exchange may contain HT greenfield format and/or RIFS sequences. See, e.g., 802.11n D2.0 § 9.13.3.1 **11.16 Phased Coexistence Operation** The following definitions apply in this subclause: — A PCO-capable AP is an HT AP that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO AP is an HT AP that is operating PCO. — A PCO BSS is an HT BSS that is operated by a PCO AP. — A PCO-capable non-AP STA is an HT non-AP STA that sets the PCO field in the HT Extended Capabilities field to the value 1. — A PCO non-AP STA is an HT non-AP STA that is associated with a PCO BSS and following PCO. — A PCO-capable STA is either a PCO-capable AP or a PCO-capable non-AP STA. — A PCO STA is either a PCO AP or a PCO non-AP STA. — A non-PCO-capable 20/40 STA is a 20/40 capable STA that sets the PCO field in the HT Extended Capabilities field to the value 0. Phased Coexistence Operation (PCO) is an optional coexistence mechanism in which a PCO AP divides time into alternating 20 MHz and 40 MHz phases (see Figure n61 (Phased Coexistence Operation)). The PCO AP reserves the 20 MHz primary channel and the 20 MHz secondary channel in turn to start the 40 MHz phase and resets the NAV in the 20 MHz channels in the opposite order to start the 20 MHz phase. Due to the protection of the 40 MHz period in both channels, it is tolerant of overlapping BSSs on both 20 MHz halves of a 40 MHz channel.

Claim 24 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	 A PCO STA that does not know the current PCO phase shall transmit in a 20 MHz PPDU. During the 40 MHz phase, a PCO STA shall transmit data frames using a 40 MHz HT PPDU and control frames using a non-HT duplicate or a 40 MHz HT PPDU, except that any CF-End frame shall be sent using a 40 MHz HT PPDU only. During the 40 MHz phase, protection is not required as in a 40 MHz BSS with Supported Channel Width Set field in the HT Capabilities Info field set to 1 and Operating Mode field in the HT Information element set to the value 0. A PCO STA shall update its NAV using Duration/ID field information from any frame received in the primary channel or 40 MHz channel. During the 20 MHz phase, a PCO STA shall only transmit frames using a 20 MHz (HT or non-HT) PPDU. The protection of a PCO STA during the 20 MHz phase is the same as protection in a 20 MHz BSS. A non-PCO-capable 20/40 STA regards the PCO BSS as 20/40 MHz BSS. The protection of a non-PCO-capable 20/40 STA that associates with the PCO BSS is the same as protection in a 20/40 MHz BSS. The PCO Transition Time field in the HT Extended Capabilities field is measured from the end of the PPDU carrying the Set PCO Phase frame. The PCO STA shall be able to receive a PPDU using the new channel width no later than the value specified in the PCO Transition Time field after the end of the PPDU carrying the Set PCO Phase frame.

Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 11.16 **20.1 Introduction** Clause 20 (High Throughput (HT) PHY specification) specifies the PHY Entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system. The HT STA shall be compliant with PHY specifications as defined in Clause 17 for operation in the 5 GHz bands, and Clauses 18 and 19 for operation in the 2.4 GHz bands . The HT features are applicable to operation in either the 2.4 GHz band or the 5 GHz bands, or both, as specified in 20.3.14 (Channel numbering and channelization). The HT OFDM PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to 4 spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using 1 to 4 spatial streams is also defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (4 spatial streams, 40 MHz bandwidth). The HT OFDM PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), or 64-QAM. Forward error correction coding (convolutional coding) is used with a coding rate of 1/2, 2/3, 3/4, or 5/6. Low-density parity-check (LDPC) codes are added . Other features at both transmit and receive sides are 400 ns short guard interval (GI), transmit beamforming, HT greenfield format , space-time block codes (STBC), and 40 MHz operation. The HT OFDM PHY defined in Clause 20 is mandatory for all equal modulation rates specified for 1 and 2 spatial streams (MCSs 0 through 15) at an AP and for 1 spatial stream (MCSs 0 through 7) at a STA using 20 MHz channel width. Support for all other MCSs in 2 to 4 spatial streams in 20 MHz, and for all MCSs in 1-4 spatial streams using 40 MHz channel width is optional. The maximum MPDU length is extended to 65535 octets. The HT PHY supports non-HT operation in the 2.4 GHz band as defined by Clause 19. It supports non-HT operation in the 5 GHz bands in as defined by Clause 17. See, e.g., 802.11n D2.0 § 20.1 **20.1.3 PPDU Formats** The PPDU format transmitted by an HT STA is determined by the TXVECTOR FORMAT, CH_BANDWIDTH , CH_OFFSET and MCS parameters as defined in this subclause. The FORMAT parameter determines the overall structure of the PPDU as follows: — *Non-HT format***:** packets of this format are structured according to the Clause 17 (OFDM) or 19 (ERP) specification. Support for Non-HT Format is mandatory. — *HT mixed format***:** packets of this format contain a preamble compatible with the non-HT receivers. The non-HT Short Training Field (L-STF), the non-HT Long Training Field (L-LTF) and the non-HT SIGNAL field are defined so they can be decoded by non-HT Clause 17 and 19 STAs. The rest of the packet cannot be decoded by Clause 17 or Clause 19 STAs. Support for HT mixed format is mandatory. — *HT greenfield format***:** HT packets of this format do not contain a non-HT compatible part. Support for HT greenfield format is optional. An HT STA that does not support the reception of an HT greenfield format packet shall be able to detect that an HT greenfield format packet is an HT transmission

Claim 24 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	(as opposed to a non-HT transmission). In this case the receiver shall decode the HT-SIG and determine if the HT-SIG cyclic redundancy check (CRC) passes. The operation of the PHY in the frequency domain is determined by the CH_BANDWIDTH and CH_OFFSET parameters. Table n55 (PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters) shows the combination of CH_BANDWIDTH and CH_OFFSET parameters that are supported. Support of 20 MHz Non-HT Format and 20 MHz HT Format with one and two spatial streams is mandatory at APs. Support of 20 Mhz Non-HT Format and 20 MHz HT Format with one spatial stream is mandatory the non-AP STAs. See, e.g., 802.11n D2.0 § 20.1.3 **20.3.2 PLCP frame format** Two formats are defined for the PLCP (PHY Layer Convergence Protocol): HT mixed format and greenfield format. These two formats are called HT formats. Figure n62 (PPDU frame format) shows the non-HT format1 and the HT formats. There is also an HT duplicate format (specified in 20.3.10.10.4) used for MCS 32 that provides the lowest rate in a 40 MHz channel. In addition to the HT formats, there is a non-HT duplicate format (specified in 20.3.10.11 (Non-HT duplicate transmission)) that duplicates the 20 MHz non-HT packet in two 20 MHz halves of a 40 MHz channel. 1 The Non-HT format is shown related to the terminology of this subclause. The Non-HT PPDU format is defined in 17.3.3 and 17.3.2. See, e.g., 802.11n D2.0 § 20.3.2 m) Divide the complex number string for each of the resulting N_{SS} spatial streams into groups of N_{SD} complex numbers, where the value of N_{SD} is determined from the CH_OFFSET field of TXVECTOR and the CH_BANDWIDTH field of TXVECTOR. Each such group is associated with one OFDM symbol in one spatial stream. In each group, the complex numbers are indexed 0 to N_{SD} -1 and mapped hereafter onto OFDM subcarriers as described in 20.3.10.10.2 (Transmission in 20 MHz HT format), 20.3.10.10.3 (Transmission in 40 MHz HT Format), 20.3.10.10.4 (Transmission in HT duplicate format), and 20.3.10.11 (Non-HT duplicate transmission). See, e.g., 802.11n D2.0 § 20.3.4.m For each group N_{ST} of subcarriers and each of the N_{TX} transmit chains, convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Determine the length of the guard interval according to the SHORT_GI field in the TXVECTOR. Refer to 20.3.10.10 (OFDM modulation) and 20.3.10.11 (Non-HT duplicate transmission) for details. See, e.g., 802.11n D2.0 § 20.3.4.r

Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	Append the OFDM symbols associated with each transmit chain one after another, starting after the final field of the PLCP preamble. Refer to 20.3.2 (PLCP frame format) and 20.3.7 (Mathematical description of signals) for details. See, e.g., 802.11n D2.0 § 20.3.4.s Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 (Mathematical description of signals) for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if antenna selection is applied. See, e.g., 802.11n D2.0 § 20.3.4.t **20.3.22 PLCP transmit procedure** There are three options for transmit PLCP procedure. The first two options, for which typical transmit procedures are shown in Figure n81 (PLCP transmit procedure (HT mixed format PPDU)) and Figure n82 (PLCP transmit procedure (HT greenfield format PPDU)), are selected if the FORMAT field of PHY-TXSTART.request(TXVECTOR) is set to HT_MF or HT_GF respectively. These transmit procedures do not describe the operation of optional features, such as LDPC. The third option is to follow the transmit procedure as in Clause 17 or 19 if the FORMAT field is set to NON_HT. Additionally, if the FORMAT field is set to NON_HT, CW indicates NON_HT_CBW20, and NON_HT_MODULATION indicates OFDM, follow the transmit procedure as in Clause 17. If the FORMAT field is set to NON_HT, CH_BANDWIDTH indicates NON_HT_CBW20, and NON_HT_MODULATION indicates other than OFDM, follow the transmit procedure as in Clause 19. And furthermore, if the FORMAT field is set to NON_HT and CH_BANDWIDTH indicates NON_HT_CBW40, follow the transmit procedure as in Clause 17 duplicated on both channels. In all these options, in order to transmit data, PHY-TXSTART.request shall be enabled so that the PHY entity shall be in the transmit state. Further, the PHY shall be set to operate at the appropriate frequency through station management via the PLME. Other transmit parameters, such as MCS Coding types and TX power, are set via the PHY-SAP with the PHY-TXSTART.request(TXVECTOR), as described in 20.2.2 (TXVECTOR and RXVECTOR parameters). A clear channel shall be indicated by PHY-CCA.indication(IDLE). The MAC considers this indication before issuing the PHY-TXSTART.request. Transmission of the PPDU shall be initiated after receiving the PHYTXSTART.request(TXVECTOR) primitive. The TXVECTOR elements for the PHY-TXSTART.request are specified in Table n56 (TXVECTOR and RXVECTOR parameters). The PLCP shall issue the parameters in the following PMD primitives to configure the PHY: — PMD_TXPWRLVL — PMD_TX_PARAMETERS — PMD_EXPANSIONS_MAT — PMD_EXPANSIONS_MAT_ON

Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	The PLCP shall then issue a PMD_TXSTART.request, and transmission of the PLCP preamble may start, based on the parameters passed in the PHY-TXSTART.request primitive. The data shall then be exchanged between the MAC and the PHY through a series of PHY-DATA.request(DATA) primitives issued by the MAC, and PHY-DATA.confirm primitives issued by the PHY. Once PLCP preamble transmission is started, the PHY entity shall immediately initiate data scrambling and data encoding. The encoding method shall be based on the LDPC_CODING, CH_BANDWIDTH, and MCS parameter of the TXVECTOR. A modulation rate change, if any, shall be initiated starting with the SERVICE field data, as described in 20.3.2 (PLCP frame format). The PHY proceeds with PSDU transmission through a series of data octet transfers from the MAC. The SERVICE field and PSDU are encoded by the encoder selected by the LDPC_CODING, CH_BANDWIDTH, and MCS parameters of the TXVECTOR as described in 20.3.3 (Transmitter block diagram). At the PMD layer, the data octets are sent in bit 0–7 order and presented to the PHY through PMD_DATA.request primitives. Transmission can be prematurely terminated by the MAC through the primitive PHY-TXEND.request. PHYTXSTART shall be disabled by the issuance of the PHY-TXEND.request. Normal termination occurs after the transmission of the final bit of the last PSDU octet, according to the number supplied in the LENGTH field. The packet transmission shall be completed and the PHY entity shall enter the receive state (i.e., PHYTXSTART shall be disabled). Each PHY-TXEND.request is acknowledged with a PHY-TXEND.confirm primitive from the PHY. If the coded PSDU (C-PSDU) is not multiples of the OFDM symbol, bits shall be stuffed to make the C-PSDU length multiples of the OFDM symbol. In the PMD, the GI or short GI shall be inserted in every OFDM symbol as a countermeasure against delay spread. A typical state machine implementation of the transmit PLCP is provided in Figure n83 (PLCP transmit state machine). Requests (.req) and confirmations(.confirm) are issued once per state as shown. This state machine does not describe the operation of optional features, such as LDPC or STBC. See, e.g., 802.11n D2.0 § 20.3.22 **20.3.6 Timing related parameters** Table n58 (Timing related constants) defines the timing related parameters. See, e.g., 802.11n D2.0 § 20.3.6 **20.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals see 17.3.2.4 In the case of either a 20 MHz Non-HT Format transmission or a 20 MHz HT Format transmission, the channel is divided into 64 sub-carriers. In the 20 MHz Non-HT Format, the signal is transmitted on sub-carriers -

Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	26 to -1 and 1 to 26, with 0 being the center (DC) carrier. In the 20 MHz HT Format, the signal is transmitted on sub-carriers -28 to -1 and 1 to 28. In the case of the 40 MHz HT Format, two adjacent 20 MHz channels are used. The channel is divided into 128 sub-carriers. The signal is transmitted on sub-carriers -58 to -2 and 2 to 58. In the case of 40 MHz HT Upper Format or 40 MHz HT Lower Format, the upper or lower 20 MHz channel is divided into 64 sub-carriers. The signal is transmitted on sub-carriers -60 to -4 in the case of a 40 MHz HT Lower Format transmission and on sub-carriers 4 to 60 in the case of a 40 MHz HT Upper Format transmission. In the case of the HT duplicate and Non-HT duplicate formats, the same data are transmitted over two adjacent 20 MHz channels. In this case, the 40 MHz channel is divided into 128 sub-carriers and the data are transmitted on carriers -58 to -6 and 6 to 58. The transmitted signal is described in complex base-band signal notation. The actual transmitted signal is related to the complex baseband signal by the following relation: $r_{RF}(t) = \mathrm{Re}\left\{ r(t)\exp\left(j2\pi f_c t \right) \right\} \quad (20\text{-}1)$ where $\mathrm{Re}\{\cdot\}$ represents the real part of a complex variable;

f_c is the center frequency of the carrier.

The transmitted RF signal is derived by modulating the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure n65 (Timing boundaries for PPDU fields).

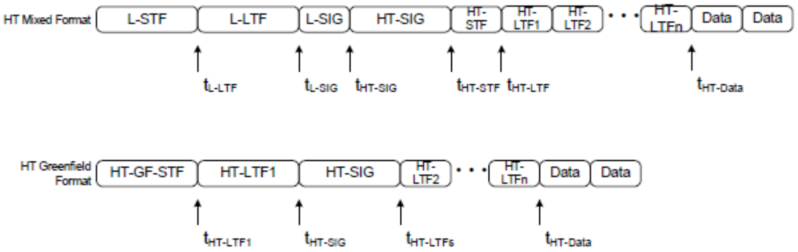


Figure n65—Timing boundaries for PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field.

In HT mixed format, the signal transmitted on transmit chain i_{TX} is

$$\begin{aligned} r_{PPDU}^{(i_{TX})}(t) = {} & r_{L-STF}^{(i_{TX})}(t) + r_{L-LTF}^{(i_{TX})}\left(t - t_{L-LTF}\right) \\ & + r_{L-SIG}^{(i_{TX})}\left(t - t_{L-SIG}\right) \\ & + r_{HT-SIG}^{(i_{TX})}\left(t - t_{HT-SIG}\right) \\ & + r_{HT-STF}^{(i_{TX})}\left(t - t_{HT-STF}\right) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r_{HT-LTF}^{(i_{TX},i_{LTF})}\left(t - t_{HT-LTF} - \left(i_{LTF} - 1\right)T_{HT-LTFs}\right) \\ & + r_{HT-DATA}^{(i_{TX})}\left(t - t_{HT-DATA}\right) \end{aligned} \qquad (20\text{-}2)$$

where

$$t_{L-LTF} = T_{L-STF}$$

$$t_{L-SIG} = t_{L-LTF} + T_{L-LTF}$$

$$t_{HT-SIG} = t_{L-SIG} + T_{L-SIG}$$

$$t_{HT-STF} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-LTF} = t_{HT-STF} + T_{HT-STF}$$

$$t_{HT-Data} = t_{HT-LTF} + N_{LTF} \cdot T_{HT-LTFs}$$

In the case of greenfield format, the transmitted signal on transmit chain i_{TX} is:

$$\begin{aligned} r^{(i_{TX})}_{PPDU}(t) = {} & r^{(i_{TX})}_{HT-GF-STF}(t) + r^{(i_{TX})}_{HT-LTF1}(t - t_{HT-LTF1}) \\ & + r^{(i_{TX})}_{HT-SIG}(t - t_{HT-SIG}) \\ & + \sum_{i_{LTF}=1}^{N_{LTF}} r^{(i_{TX}, i_{LTF})}_{HT-LTF}(t - t_{HT-LTFs} - (i_{LTF} - 2)T_{HT-LTFs}) \\ & + r^{(i_{TX})}_{HT-DATA}(t - t_{HT-DATA}) \end{aligned} \qquad (20\text{-}3)$$

where

$$t_{HT-LTF1} = T_{HT-GF-STF}$$

$$t_{HT-SIG} = t_{HT-LTF1} + T_{HT-LTF1}$$

$$t_{HT-LTFs} = t_{HT-SIG} + T_{HT-SIG}$$

$$t_{HT-Data} = t_{HT-LTFs} + (N_{LTF} - 1) \cdot T_{HT-LTFs}$$

Each baseband waveform, $r^{(i_{TX})}_{\text{Field}}(t)$, is defined via the discrete Fourier transform as

$$r^{(i_{TX})}_{\text{Field}}(t) = \frac{1}{\sqrt{N^{\text{Tone}}_{\text{Field}} \cdot N_{TX}}} w_{T_{\text{Field}}}(t) \sum_{k} \Upsilon_k X^{(i_{TX})}_k \exp(j2\pi k \Delta_F t) \qquad (20\text{-}4)$$

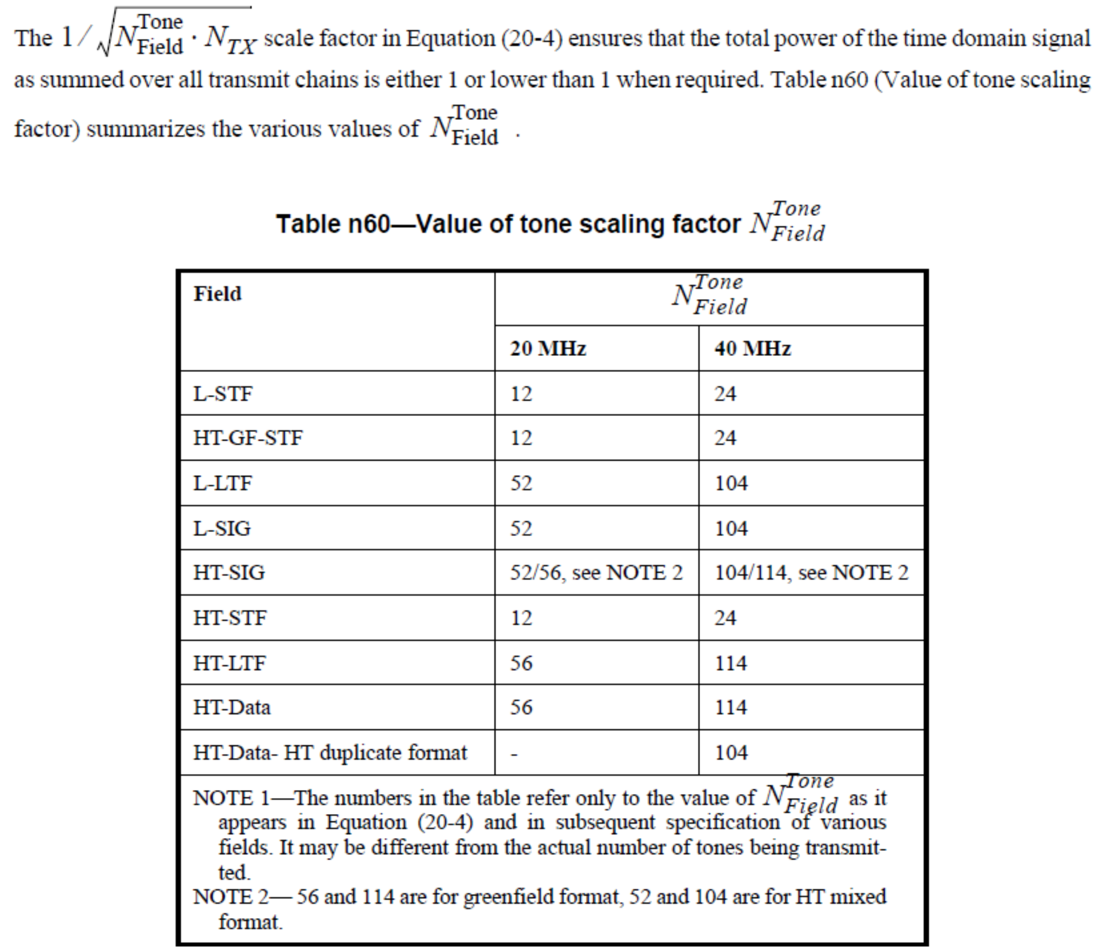
This general representation holds for all fields. A suggested definition of the windowing function , $w_{T_{\text{Field}}}(t)$, is given in 17.3.2.4. The frequency-domain symbols $X^{(i_{TX})}_k$ represent the output of any spatial processing in subcarrier k for Tx chain i_{TX} required for the field.

The function Υ_k is used to represent a rotation of the upper tones in a 40 MHz channel:

$$\Upsilon_k = \begin{cases} 1,\ k \le 0, \text{ in a 40 MHz channel} \\ j,\ k > 0, \text{ in a 40 MHz channel} \end{cases} \qquad (20\text{-}5)$$

$$\Upsilon_k = 1, \text{ in a 20 MHz channel} \qquad (20\text{-}6)$$

Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0



The $1/\sqrt{N_{\text{Field}}^{\text{Tone}} \cdot N_{TX}}$ scale factor in Equation (20-4) ensures that the total power of the time domain signal as summed over all transmit chains is either 1 or lower than 1 when required. Table n60 (Value of tone scaling factor) summarizes the various values of $N_{\text{Field}}^{\text{Tone}}$.

Table n60—Value of tone scaling factor N_{Field}^{Tone}

Field	N_{Field}^{Tone}	
	20 MHz	**40 MHz**
L-STF	12	24
HT-GF-STF	12	24
L-LTF	52	104
L-SIG	52	104
HT-SIG	52/56, see NOTE 2	104/114, see NOTE 2
HT-STF	12	24
HT-LTF	56	114
HT-Data	56	114
HT-Data- HT duplicate format	-	104

NOTE 1—The numbers in the table refer only to the value of N_{Field}^{Tone} as it appears in Equation (20-4) and in subsequent specification of various fields. It may be different from the actual number of tones being transmitted.

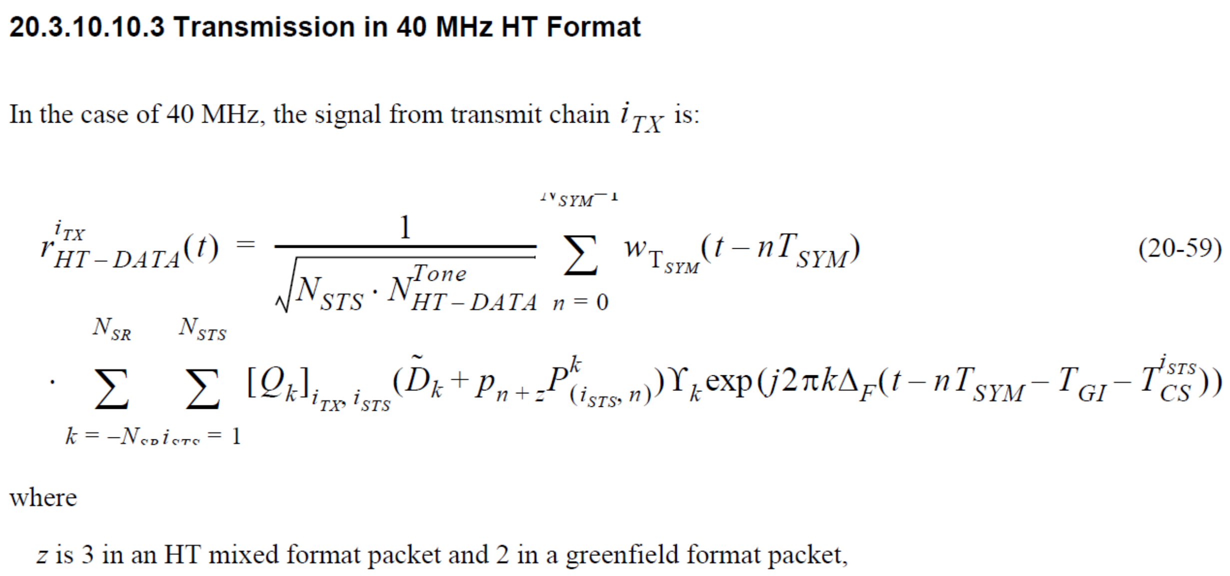
NOTE 2— 56 and 114 are for greenfield format, 52 and 104 are for HT mixed format.

See, e.g., 802.11n D2.0 § 20.3.7 and Figure n65

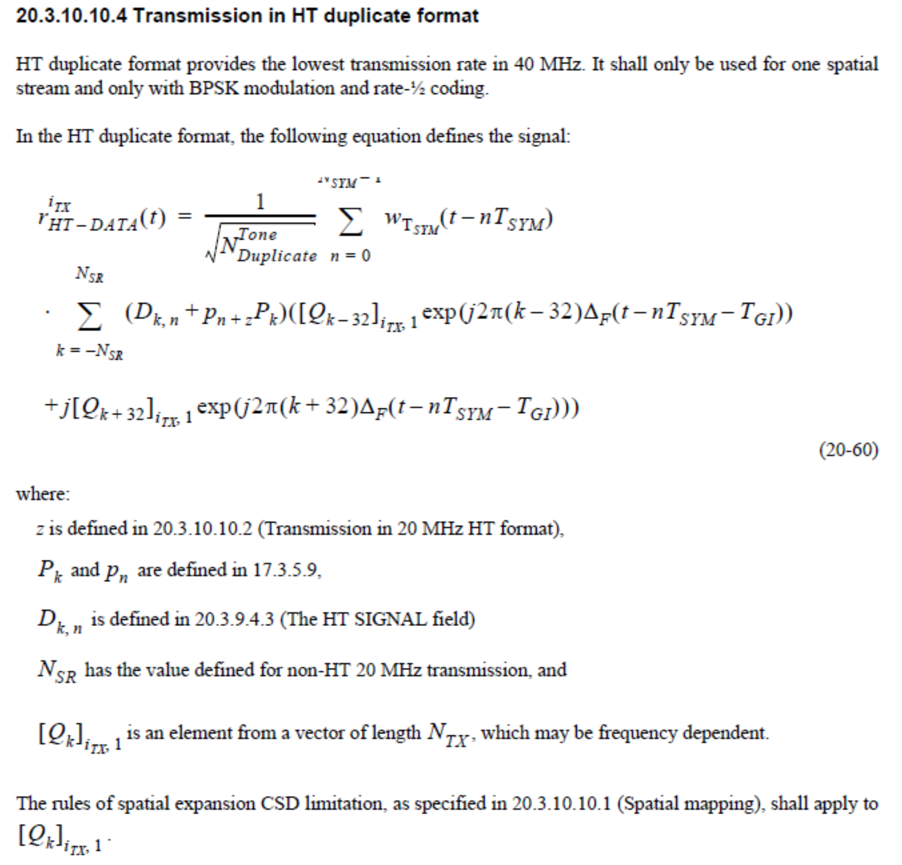
20.3.8 Transmission in the upper/lower 20 MHz of a 40 MHz channel

When transmitting in the upper/lower 20 MHz portion of a 40 MHz channel, the mathematical definition of transmission shall follow that of a 20 MHz channel with in Equation (20-1) replaced by .

Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.8 **20.3.9.4.3 The HT SIGNAL field** The HT SIGNAL field is used to carry information required to interpret the HT packet formats. The fields of the HT SIGNAL field are described in Table n63 (Fields of HT SIGNAL field). The structure of the HT-SIG1 and HT-SIG2 fields is defined in Figure n67 (Format of HT-SIG1 and HTSIG2). … $D_{k,n} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M^r(k),n}, \text{ otherwise} \end{cases}$ See, e.g., 802.11n D2.0 § 20.3.9.4.3 **20.3.10.10.2 Transmission in 20 MHz HT format** The signal from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM})$ (20-58) $\cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} [Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k,n} + p_{n+z} P^k_{(i_{STS},n)}) \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ where: z is 3 in an HT mixed format packet and 2 in a greenfield format packet,

Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.10.10.2  **20.3.10.10.3 Transmission in 40 MHz HT Format** In the case of 40 MHz, the signal from transmit chain i_{TX} is: $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS}\cdot N_{HT-DATA}^{Tone}}}\sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}}\sum_{i_{STS}=1}^{N_{STS}}[Q_k]_{i_{TX},i_{STS}}(\tilde{D}_k + p_{n+z}P^k_{(i_{STS},n)})\Upsilon_k \exp(j2\pi k\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{STS}}))$ (20-59) where z is 3 in an HT mixed format packet and 2 in a greenfield format packet, See, e.g., 802.11n D2.0 § 20.3.10.10.3

<table>
<tr><th>Claim 24 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>



20.3.10.10.4 Transmission in HT duplicate format

HT duplicate format provides the lowest transmission rate in 40 MHz. It shall only be used for one spatial stream and only with BPSK modulation and rate-½ coding.

In the HT duplicate format, the following equation defines the signal:

$$r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} (D_{k,n} + p_{n+z}P_k)([Q_{k-32}]_{i_{TX},1} \exp(j2\pi(k-32)\Delta_F(t - nT_{SYM} - T_{GI})) + j[Q_{k+32}]_{i_{TX},1} \exp(j2\pi(k+32)\Delta_F(t - nT_{SYM} - T_{GI}))) \qquad (20\text{-}60)$$

where:

z is defined in 20.3.10.10.2 (Transmission in 20 MHz HT format),

P_k and p_n are defined in 17.3.5.9,

$D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field)

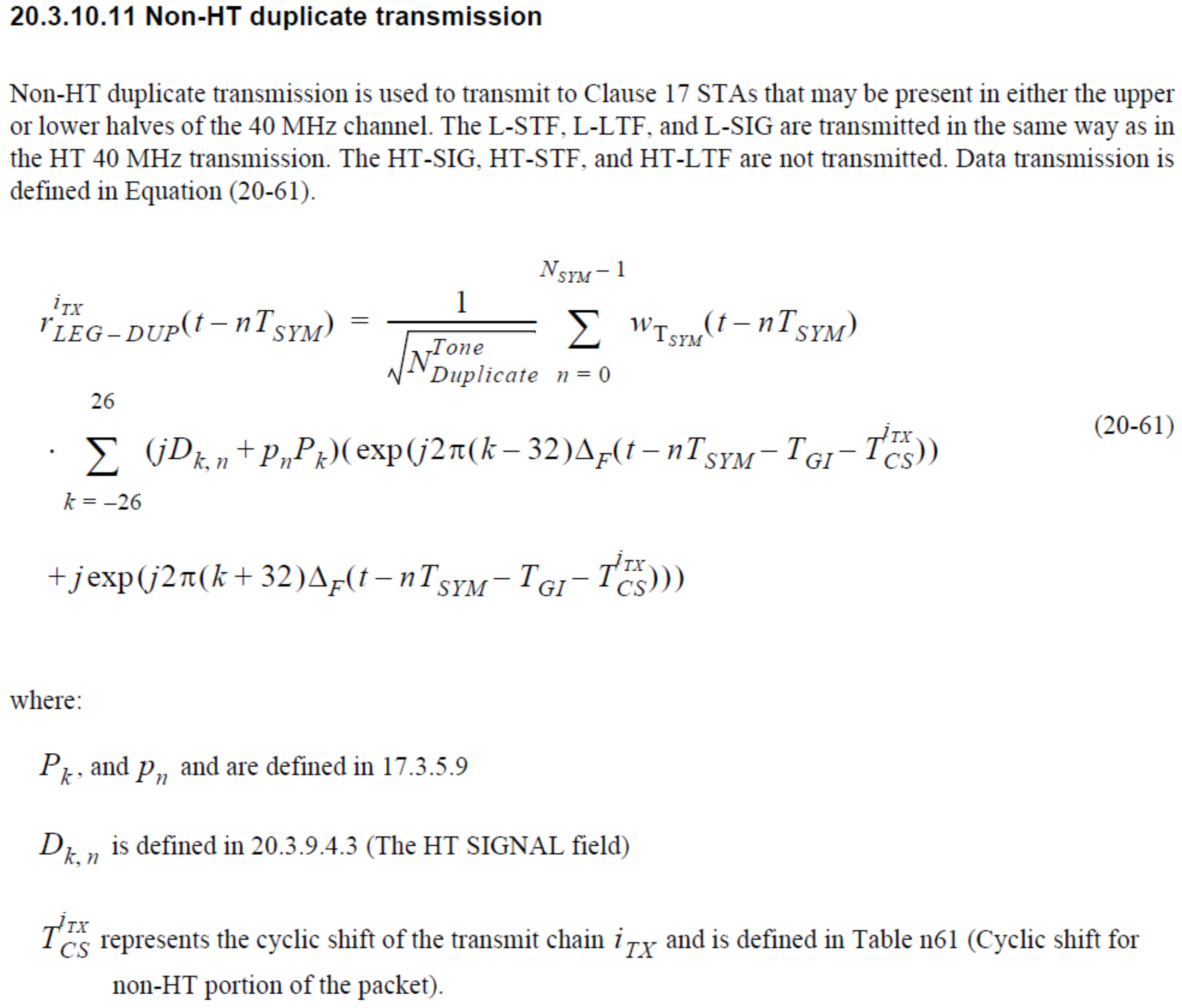
N_{SR} has the value defined for non-HT 20 MHz transmission, and

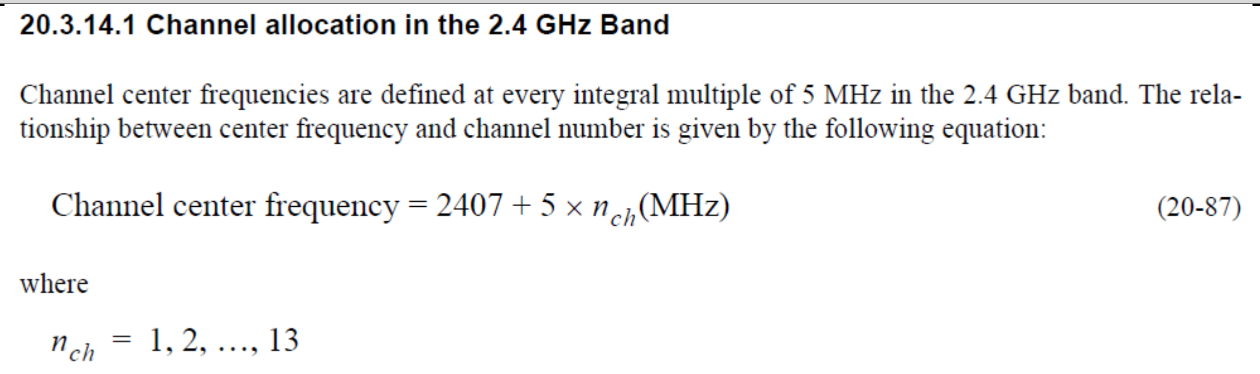
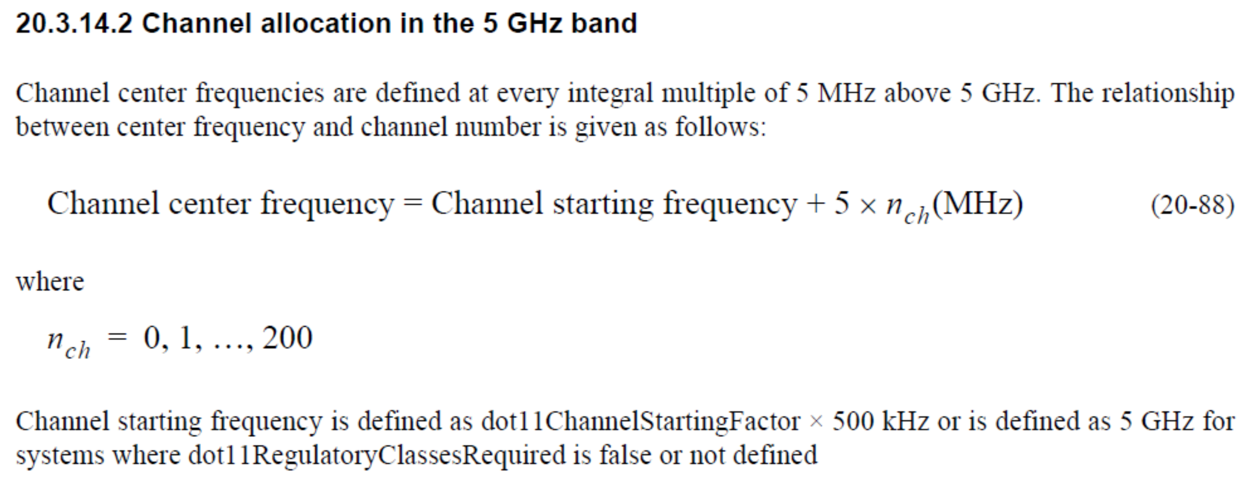
$[Q_k]_{i_{TX},1}$ is an element from a vector of length N_{TX}, which may be frequency dependent.

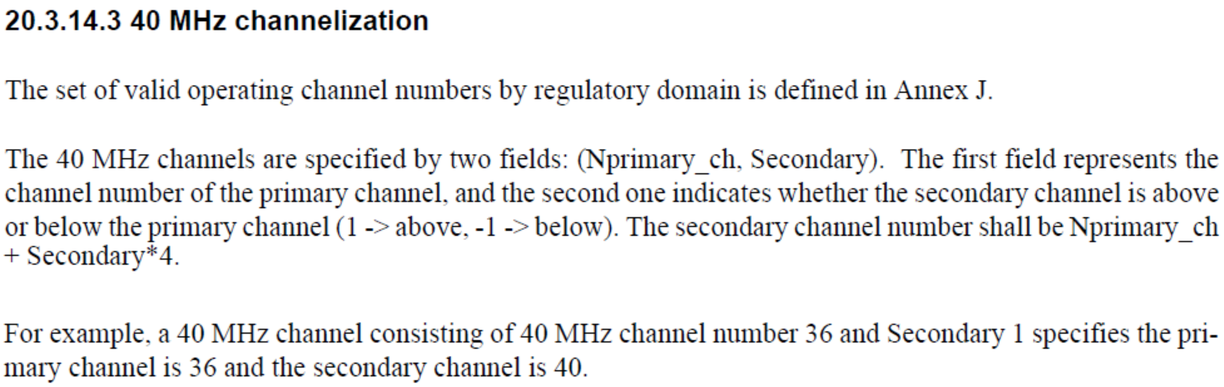
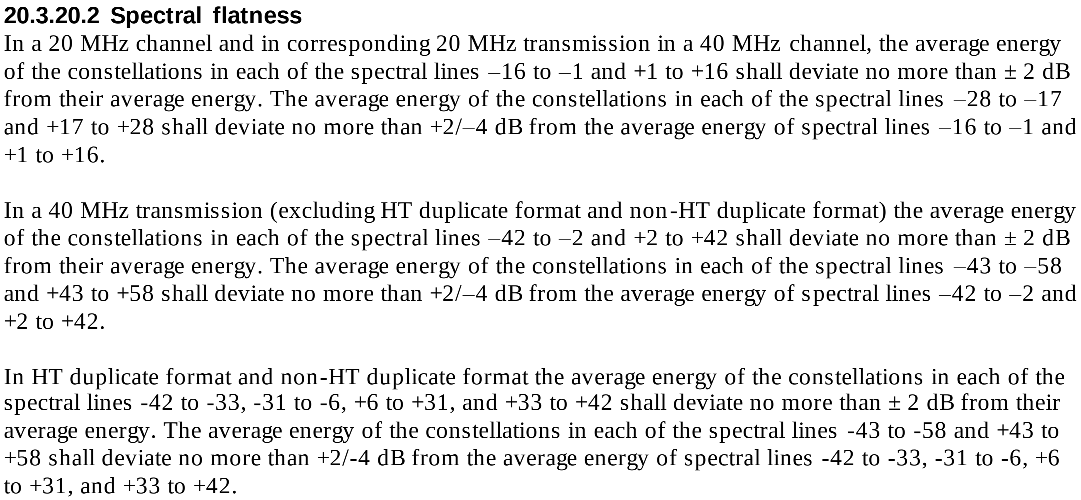
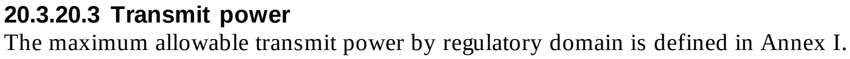
The rules of spatial expansion CSD limitation, as specified in 20.3.10.10.1 (Spatial mapping), shall apply to $[Q_k]_{i_{TX},1}$.

See, e.g., 802.11n D2.0 § 20.3.10.10.4

</td></tr>
</table>

Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.10.11 Non-HT duplicate transmission** Non-HT duplicate transmission is used to transmit to Clause 17 STAs that may be present in either the upper or lower halves of the 40 MHz channel. The L-STF, L-LTF, and L-SIG are transmitted in the same way as in the HT 40 MHz transmission. The HT-SIG, HT-STF, and HT-LTF are not transmitted. Data transmission is defined in Equation (20-61). $r_{LEG-DUP}^{i_{TX}}(t-nT_{SYM}) = \frac{1}{\sqrt{N_{Duplicate}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t-nT_{SYM}) \cdot \sum_{k=-26}^{26} (jD_{k,n}+p_nP_k)(\exp(j2\pi(k-32)\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{TX}})) + j\exp(j2\pi(k+32)\Delta_F(t-nT_{SYM}-T_{GI}-T_{CS}^{i_{TX}})))$ (20-61) where: P_k, and p_n and are defined in 17.3.5.9 $D_{k,n}$ is defined in 20.3.9.4.3 (The HT SIGNAL field) $T_{CS}^{i_{TX}}$ represents the cyclic shift of the transmit chain i_{TX} and is defined in Table n61 (Cyclic shift for non-HT portion of the packet). See, e.g., 802.11n D2.0 § 20.3.10.11

Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.1 Channel allocation in the 2.4 GHz Band** Channel center frequencies are defined at every integral multiple of 5 MHz in the 2.4 GHz band. The relationship between center frequency and channel number is given by the following equation: $\text{Channel center frequency} = 2407 + 5 \times n_{ch}(\text{MHz})$ (20-87) where $n_{ch} = 1, 2, \ldots, 13$ See, e.g., 802.11n D2.0 § 20.3.14.1  **20.3.14.2 Channel allocation in the 5 GHz band** Channel center frequencies are defined at every integral multiple of 5 MHz above 5 GHz. The relationship between center frequency and channel number is given as follows: $\text{Channel center frequency} = \text{Channel starting frequency} + 5 \times n_{ch}(\text{MHz})$ (20-88) where $n_{ch} = 0, 1, \ldots, 200$ Channel starting frequency is defined as dot11ChannelStartingFactor × 500 kHz or is defined as 5 GHz for systems where dot11RegulatoryClassesRequired is false or not defined See, e.g., 802.11n D2.0 § 20.3.14.2

Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **20.3.14.3 40 MHz channelization** The set of valid operating channel numbers by regulatory domain is defined in Annex J. The 40 MHz channels are specified by two fields: (Nprimary_ch, Secondary). The first field represents the channel number of the primary channel, and the second one indicates whether the secondary channel is above or below the primary channel (1 -> above, -1 -> below). The secondary channel number shall be Nprimary_ch + Secondary*4. For example, a 40 MHz channel consisting of 40 MHz channel number 36 and Secondary 1 specifies the primary channel is 36 and the secondary channel is 40. See, e.g., 802.11n D2.0 § 20.3.14.3  **20.3.20.2 Spectral flatness** In a 20 MHz channel and in corresponding 20 MHz transmission in a 40 MHz channel, the average energy of the constellations in each of the spectral lines –16 to –1 and +1 to +16 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –28 to –17 and +17 to +28 shall deviate no more than +2/–4 dB from the average energy of spectral lines –16 to –1 and +1 to +16. In a 40 MHz transmission (excluding HT duplicate format and non-HT duplicate format) the average energy of the constellations in each of the spectral lines –42 to –2 and +2 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines –43 to –58 and +43 to +58 shall deviate no more than +2/–4 dB from the average energy of spectral lines –42 to –2 and +2 to +42. In HT duplicate format and non-HT duplicate format the average energy of the constellations in each of the spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42 shall deviate no more than ± 2 dB from their average energy. The average energy of the constellations in each of the spectral lines -43 to -58 and +43 to +58 shall deviate no more than +2/-4 dB from the average energy of spectral lines -42 to -33, -31 to -6, +6 to +31, and +33 to +42. See, e.g., 802.11n D2.0 § 20.3.20.2  **20.3.20.3 Transmit power** The maximum allowable transmit power by regulatory domain is defined in Annex I.

Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	See, e.g., 802.11n D2.0 § 20.3.20.3

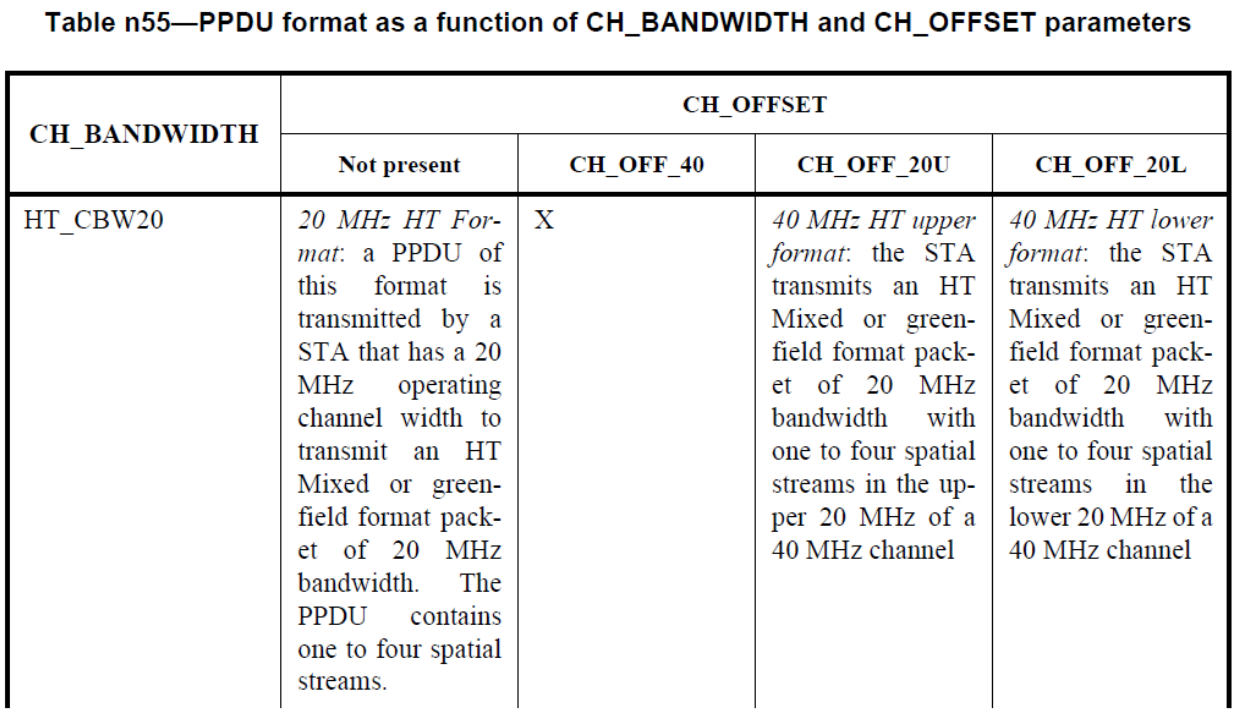
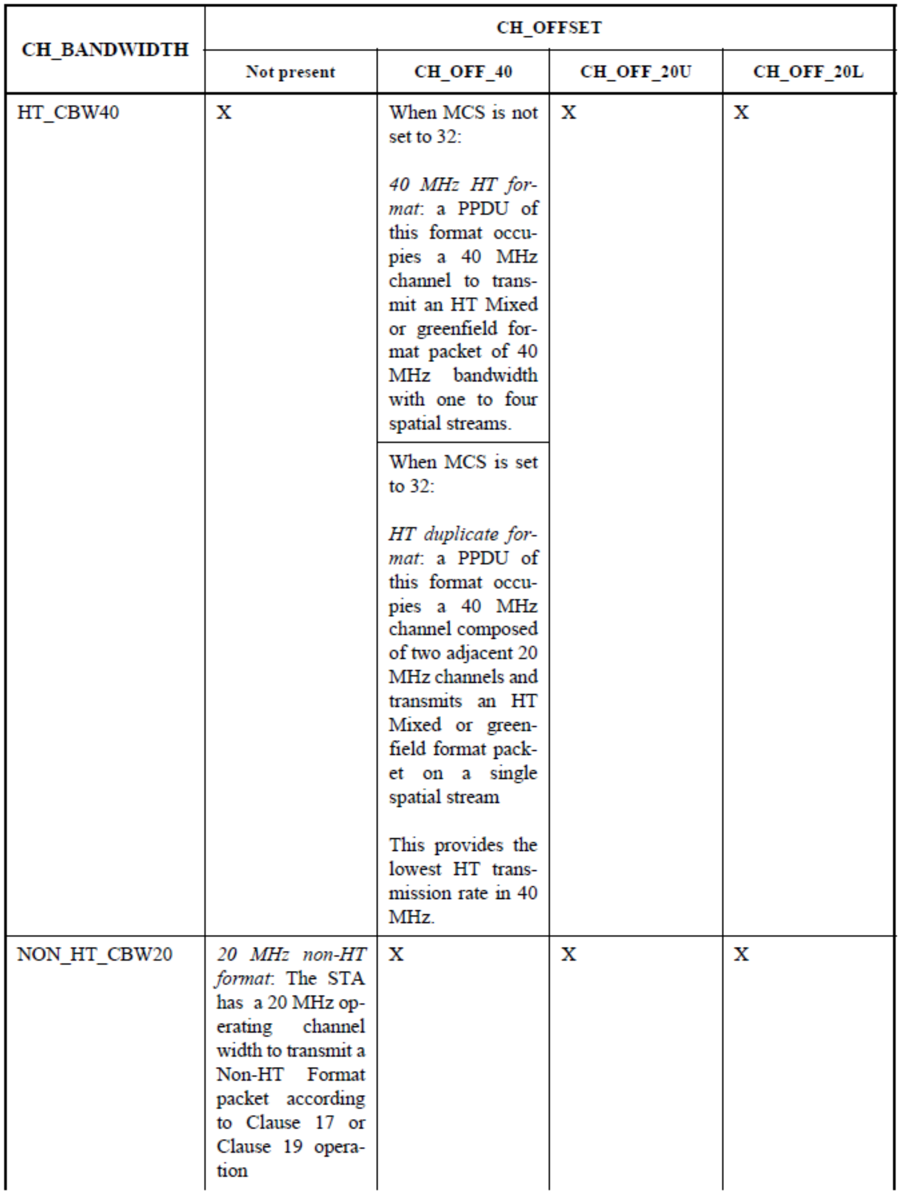
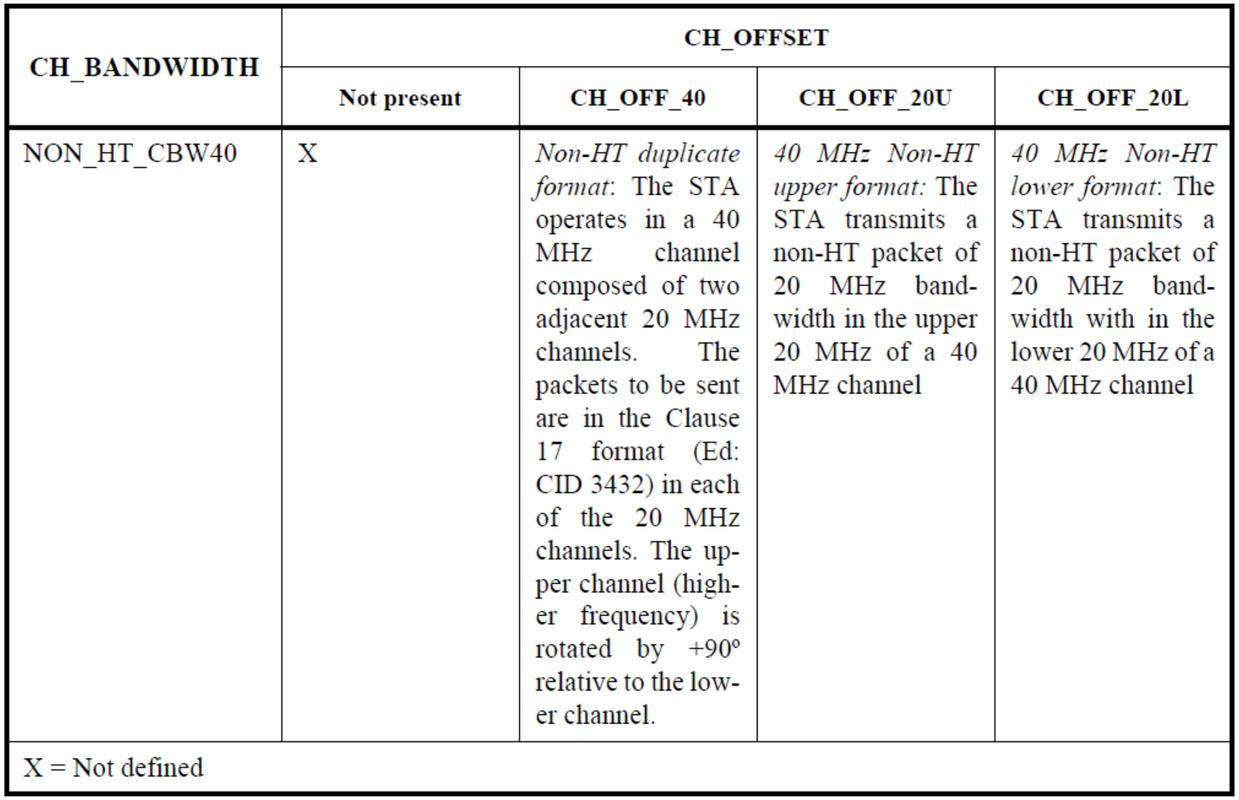


Table n55—PPDU format as a function of CH_BANDWIDTH and CH_OFFSET parameters

CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW20	*20 MHz HT Format*: a PPDU of this format is transmitted by a STA that has a 20 MHz operating channel width to transmit an HT Mixed or greenfield format packet of 20 MHz bandwidth. The PPDU contains one to four spatial streams.	X	*40 MHz HT upper format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the upper 20 MHz of a 40 MHz channel	*40 MHz HT lower format*: the STA transmits an HT Mixed or greenfield format packet of 20 MHz bandwidth with one to four spatial streams in the lower 20 MHz of a 40 MHz channel



CH_BANDWIDTH	CH_OFFSET			
	Not present	CH_OFF_40	CH_OFF_20U	CH_OFF_20L
HT_CBW40	X	When MCS is not set to 32: *40 MHz HT format*: a PPDU of this format occupies a 40 MHz channel to transmit an HT Mixed or greenfield format packet of 40 MHz bandwidth with one to four spatial streams. When MCS is set to 32: *HT duplicate format*: a PPDU of this format occupies a 40 MHz channel composed of two adjacent 20 MHz channels and transmits an HT Mixed or greenfield format packet on a single spatial stream This provides the lowest HT transmission rate in 40 MHz.	X	X
NON_HT_CBW20	*20 MHz non-HT format*: The STA has a 20 MHz operating channel width to transmit a Non-HT Format packet according to Clause 17 or Clause 19 operation	X	X	X

<table>
<tr><th>Claim 24 of the ’802 Patent</th><th>Prior Art Reference – 802.11n D2.0</th></tr>
<tr><td></td><td>

<table>
<tr><th rowspan="2">CH_BANDWIDTH</th><th colspan="4">CH_OFFSET</th></tr>
<tr><th>Not present</th><th>CH_OFF_40</th><th>CH_OFF_20U</th><th>CH_OFF_20L</th></tr>
<tr><td>NON_HT_CBW40</td><td>X</td><td><i>Non-HT duplicate format</i>: The STA operates in a 40 MHz channel composed of two adjacent 20 MHz channels. The packets to be sent are in the Clause 17 format (Ed: CID 3432) in each of the 20 MHz channels. The upper channel (higher frequency) is rotated by +90º relative to the lower channel.</td><td><i>40 MHz Non-HT upper format:</i> The STA transmits a non-HT packet of 20 MHz bandwidth in the upper 20 MHz of a 40 MHz channel</td><td><i>40 MHz Non-HT lower format</i>: The STA transmits a non-HT packet of 20 MHz bandwidth with in the lower 20 MHz of a 40 MHz channel</td></tr>
<tr><td colspan="5">X = Not defined</td></tr>
</table>
See, e.g., 802.11n D2.0 Table n55
</td></tr>
</table>

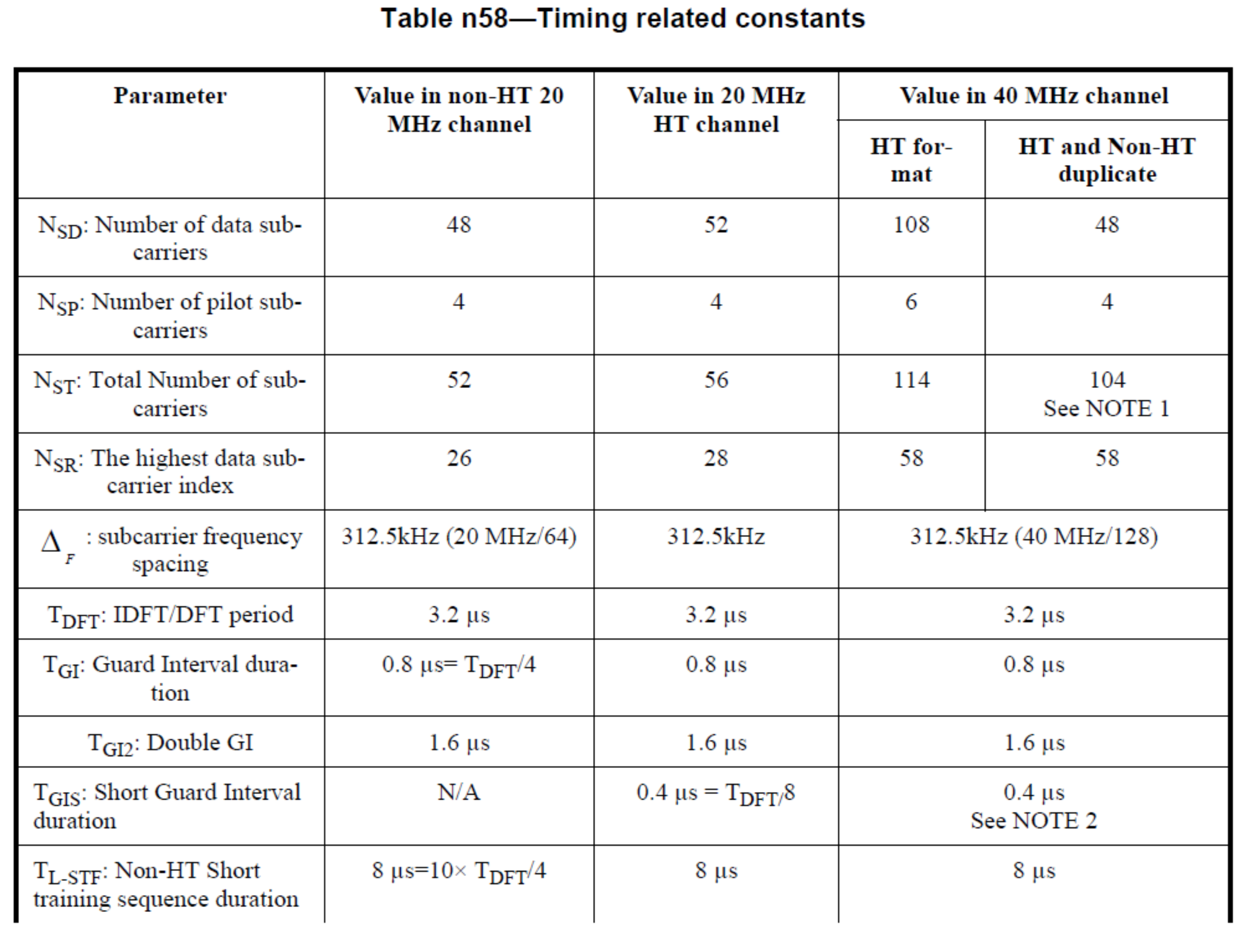
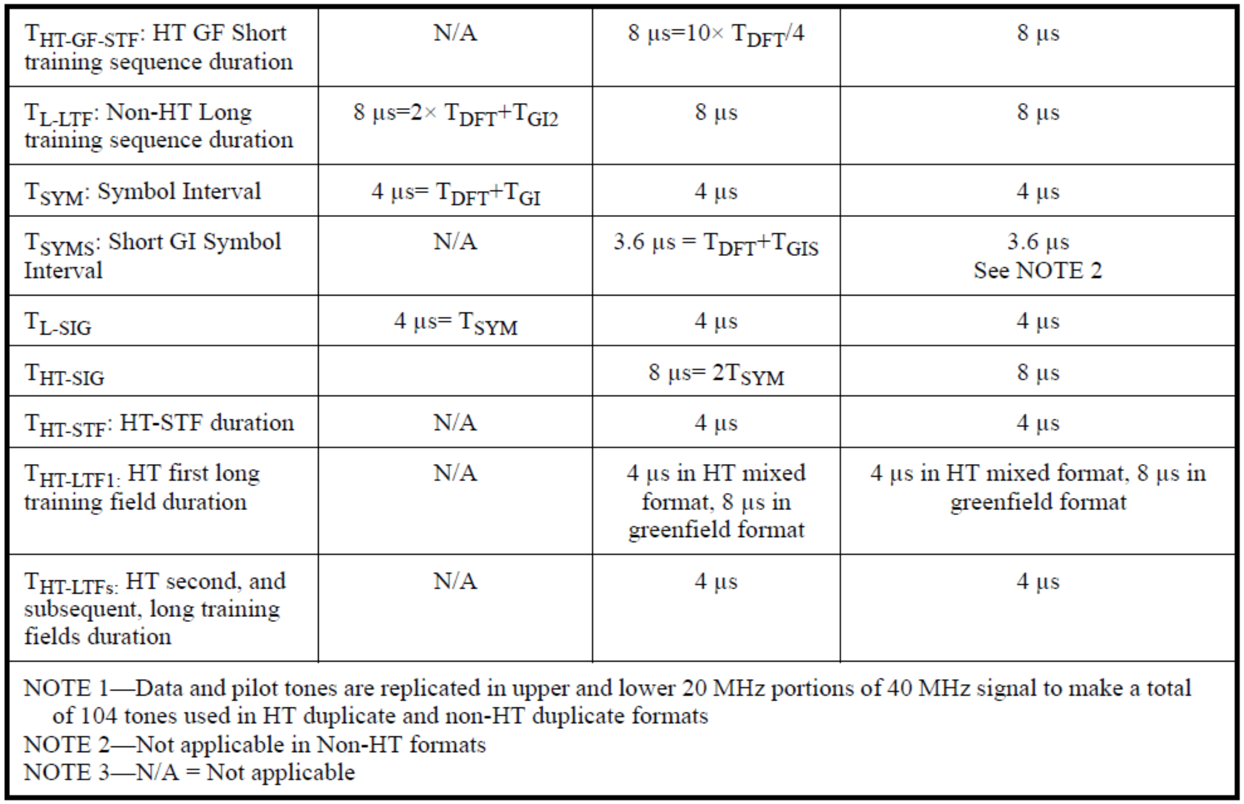
Claim 24 of the '802 Patent	Prior Art Reference – 802.11n D2.0
	

Table n58—Timing related constants

Parameter	Value in non-HT 20 MHz channel	Value in 20 MHz HT channel	Value in 40 MHz channel	
			HT format	HT and Non-HT duplicate
N_{SD}: Number of data subcarriers	48	52	108	48
N_{SP}: Number of pilot subcarriers	4	4	6	4
N_{ST}: Total Number of subcarriers	52	56	114	104 See NOTE 1
N_{SR}: The highest data subcarrier index	26	28	58	58
Δ_F : subcarrier frequency spacing	312.5kHz (20 MHz/64)	312.5kHz	312.5kHz (40 MHz/128)	
T_{DFT}: IDFT/DFT period	3.2 µs	3.2 µs	3.2 µs	
T_{GI}: Guard Interval duration	0.8 µs= $T_{DFT}/4$	0.8 µs	0.8 µs	
T_{GI2}: Double GI	1.6 µs	1.6 µs	1.6 µs	
T_{GIS}: Short Guard Interval duration	N/A	0.4 µs = $T_{DFT}/8$	0.4 µs See NOTE 2	
$T_{L\text{-}STF}$: Non-HT Short training sequence duration	8 µs=10× $T_{DFT}/4$	8 µs	8 µs	

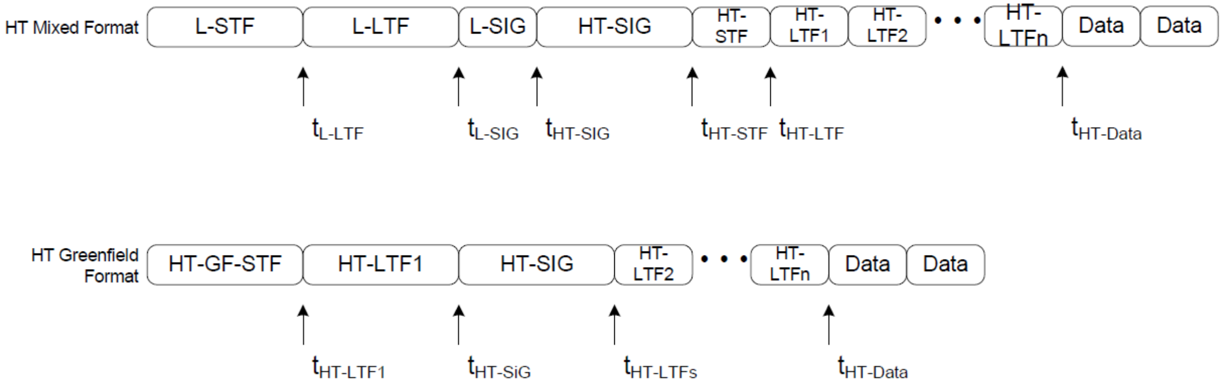
Claim 24 of the '802 Patent	**Prior Art Reference – 802.11n D2.0**



$T_{HT-GF-STF}$: HT GF Short training sequence duration	N/A	8 µs=10× T_{DFT}/4	8 µs
T_{L-LTF}: Non-HT Long training sequence duration	8 µs=2× T_{DFT}+T_{GI2}	8 µs	8 µs
T_{SYM}: Symbol Interval	4 µs= T_{DFT}+T_{GI}	4 µs	4 µs
T_{SYMS}: Short GI Symbol Interval	N/A	3.6 µs = T_{DFT}+T_{GIS}	3.6 µs See NOTE 2
T_{L-SIG}	4 µs= T_{SYM}	4 µs	4 µs
T_{HT-SIG}		8 µs= 2T_{SYM}	8 µs
T_{HT-STF}: HT-STF duration	N/A	4 µs	4 µs
$T_{HT-LTF1}$: HT first long training field duration	N/A	4 µs in HT mixed format, 8 µs in greenfield format	4 µs in HT mixed format, 8 µs in greenfield format
$T_{HT-LTFs}$: HT second, and subsequent, long training fields duration	N/A	4 µs	4 µs

NOTE 1—Data and pilot tones are replicated in upper and lower 20 MHz portions of 40 MHz signal to make a total of 104 tones used in HT duplicate and non-HT duplicate formats
NOTE 2—Not applicable in Non-HT formats
NOTE 3—N/A = Not applicable

See, e.g., 802.11n D2.0 Table n58

Claim 24 of the ’802 Patent	Prior Art Reference – 802.11n D2.0
	 **Figure n65—Timing boundaries for PPDU fields** See, e.g., 802.11n D2.0 Figure n65 Furthermore, this claim element is obvious in light of 802.11n D2.0 itself, when combined with any of the other references as charted for this claim element in Exs. A-1–A-31, First Supplemental Ex. A-Obviousness Chart, and/or when combined with the knowledge of one of ordinary skill in the art. Motivations to combine may come from the knowledge of the person of ordinary skill themselves, or from the known problems and predictable solutions as embodied in these references. Further motivations to combine references and additional details may be found in the Cover Pleading and First Supplemental Ex. A-Obviousness Chart.